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MODERN SEAMANSHIP.

BY

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WITH 136 FULL PAGE PLATES.

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PREFACE.

An attempt is made, in the following pages, to cover a wider field than that covered by most of the existing works on Seamanship.

The admirable treatises of Luce, Nares, and Alston, originating in the days when seamanship was almost wholly concerned with the fitting and handling of vessels under sail, have preserved through later editions the general characteristics which they naturally assumed in the beginning. These treatises will never be out of date until the time, still far in the future, when sails shall have been entirely driven out by steam. It will hardly be denied, however, that the Steamer has long since established its claim to consideration in Seamanship, and that there is room for a work in which this claim shall be more fully recognized than in the treatises above referred to. The excellent work of Captains Todd and Whall, "Practical Seamanship for the Merchant Service," deals more fully than either of its predecessors with the handling of steamers; but its point of view is, as its name implies, primarily and almost exclusively that of the Merchant Service.

Shortly after the present work was begun, a circular letter was addressed to officers of the merchant service and extensively circulated through the Branch Hydrographic Offices at New York, Philadelphia, Baltimore and Norfolk, requesting the views of the officers addressed, upon the following subjects:

I. Taking a Disabled Vessel in Tow in Bad Weather.
II. Rescuing the Crew of a Wreck in Bad Weather.
III. Rescuing a Man Overboard.
IV. Lying-to in a Gale.
V. The Stowage and Handling of Boats.
VI. Manœuvring Single-screw and Twin-screw Vessels.
VII. Floating a Stranded Vessel.
VIII. Handling Steamers around a Dock.

The answers received to these questions were unexpectedly numerous and complete. More than forty prominent officers of the Merchant Service replied, many of them writing out their views and describing their experiences with a fullness of detail far beyond anything that could have been anticipated.

The thanks of the author are due particularly to the following for letters or for personal interviews covering the above points: Capt. W. H. Thompson, S. S. Belgenland; Capt. T. Evans, S. S. Runo; Capt. J. Dann, S. S. Southwark; 1st Officer T. Anfindsen, S. S. Southwark; Capt. J. C. Jameson, S. S. St. Paul; Capt. H. E. Nickels, S. S. Friesland; Capt. G. J. Loveridge, S. S. Buffalo; Capt. F. M. Howes, S. S. Kershaw; Capt. T. J. Thorkildsen, S. S. Trojan; Capt. Otto Neilsen, S. S. Pennland; Capt. H. Doxrud, S. S. Noordland; Capt. C. O. Rockwell, Clyde S. S. Co.; Capt. S. W. Watkins, S. S. Montana; Capt. Anders Beer, S. S. Nordkyn; Capt. J. M. Johnston, S. S. Sardinian; Capt. A. R. Mills, S. S. Westernland; Capt. J. S. Garvin, S. S. Cherokee; Capt. Robt. B. Quick, S. S. El Cid; Capt. Wm. J. Roberts, S. S. New York; Capt. T. Richardson, S. S. Noranmore; Capt. E. O. Marshall, S. S. Maryland; 1st Officer H. S. Lane, S. S. Maryland; Capt. W. F. Bingham, S. S. Marengo; Capt. R. Gowing, S. S. Greatham; Capt. H. J. Byrne, U. S. A. T. McPherson; Capt. Paul Grosch, S. S. Stuttgart; Capt. Geo. Schrotter, S. S. Belgravia; Capt. F. C. Saunders, S. S. English King; Capt. Chas. Cabot, S. S. Venango; Capt. Chas. Pinkham, S. S. Queen Wilhelmina; Capt. A. Traue, S. S. München; Capt. W. Thomas, S. S. Quernmore; Capt. H. O. Nickerson, Fall River Line; Capt. Geo. Lane, Baltimore Steam Packet Co.

Important assistance was received from Naval Constructor W. J. Baxter, U. S. Navy, who prepared Chapters I and XVIII; and from Lieutenant E. E. Hayden, U. S. Navy, who contributed several Charts and much valuable information upon Meteorology, for Chapter XIX.

Chapter V was suggested by a paper, "Mechanical Appliances on board Ship," by Captain Thomas Mackenzie, issued by the London Shipmasters' Society as No. 29 of their valuable series of publications.

It would be impossible to mention all the Naval Officers who have assisted the author with criticism and suggestions; but acknowledgment is especially due to Lieut.-Commander A. W. Grant, Lieut. John Hood, Lieut. W. R. M. Field, Lieut. John Gow, Lieut.-Commander W. F. Worthington, Commander J. E. Pillsbury, Lieut. V. S. Nelson, Lieut. Ridgely Hunt, and Chief Boatswain W. L. Hill, all of the United States Navy.

Above all, acknowledgment is due to Chief Boatswain C. F. Pierce, U. S. Navy, who not only assisted in the preparation of many parts of the text, but prepared sketches for fully one half the illustrations of the volume.

Austin M. Knight.

United States Naval Academy,
April 1, 1901.

TABLE OF CONTENTS.

CHAPTER I.

THE HULL AND FITTINGS OF A SHIP.

Types of Ships.—Construction of the Hull.—Steering Gear and Rudder. — Ventilation. — Drainage. — Firemain. — Water-tightness. — Miscellaneous.

CHAPTER II.

ROPE—KNOTTING AND SPLICING.

§ I. Rope. Varieties of Rope.—Manufacture of Rope.—Hemp.—Manila.—Coir.—Small Stuff.—Characteristics of Rope.—Wire-Rope.—Manufacture and Uses of Wire-Rope.—Strength of Rope. § II. Knotting and Splicing. Working in Hemp and Manila.—Working in Wire.

CHAPTER III.

SPARS AND STANDING RIGGING.

§ I. Masts. Details of Masts and their Fittings.—Military Masts. § II. Yards. Details of Yards and their Fittings.—Double Topsail and Topgallant Yards.—Bowsprit and Head Booms. § III. Standing Rigging. Details of Standing Rigging.—Fitting Rigging.—Rigging Ship.—To Get in and Send up a Topmast.—To Get in a Main Yard.—To Get in a Topsail Yard and Send it up.—To Send down a Topsail Yard.—To Send down a Lower Yard.—To House Topmasts.—To Send out the Jib-boom.—To Send up Topgallant Masts.—To Send up a Topgallant Yard.—To Send down a Topgallant Yard.—To Send down a Topgallant Mast.

CHAPTER IV.

SAILS AND RUNNING GEAR.

§ I. Sails. Material of Sails.—Canvas.—Details of Sails.—Sailmaking. —Storm Sails.—Studding Sails.—Double Topsails and Topgallant Sails. § II. Running Gear. Halliards.—Braces.—Lifts.—Sheets.—Clew-lines, &c.

CHAPTER V.

MECHANICAL APPLIANCES ON SHIPBOARD.

The Composition and Resolution of Forces.—Forces Acting on a Boom in Lifting a Weight.—The Span.—The Lever.

CHAPTER VI.

BLOCKS AND TACKLES.

§ I. Blocks. The Parts of a Block.—Various Kinds of Blocks.—Strapping Blocks. § II. Tackles. Principle of a Tackle.—Effect of Friction.—Power of Tackles. § III. Various Forms of Tackles. § IV. Practical Rules and Examples for Ropes, Blocks and Tackles.

CHAPTER VII.

HANDLING HEAVY WEIGHTS.

§ I. Rigging Yards and Derricks. Use of Yards and Masts.—Use of a Span.—Use of a Boom.—To Rig a Derrick. § II. Practical Examples in Handling Weights.

CHAPTER VIII.

THE COMPASS, LOG AND LEAD.

§ I. The Compass. Description of a Compass.—The Pelorus. § II. The Log. The Chip-log.—Patent Logs. § III. The Lead. The Hand Lead.—The Deep-Sea Lead.—Sounding Machines.—Description of Sir William Thomson's Sounding Machine and its Use.

CHAPTER IX.

BOATS.

§ I. Types of Boats. The Whale Boat.—Boats for Merchant Ships.—Boats for Men-of-War.—The Build of Boats.—The Classification of Boats. § II. The Stowage and Handling of Boats. Carrying Boats on Shipboard.—Forms of Davits, Cradles, &c.—Equipment of Boats.—Detaching Apparatus.—Lowering and Hoisting Boats. § III. Rig of Ships' Boats for Sailing. § IV. Handling Boats under Sail. § V. Handling Boats under Oars. Caught in a Gale.—Running a Line. § VI. Notes on the Handling and Care of the Steam Launches of Men-of-War.

CHAPTER X.

HANDLING BOATS IN A SURF.

§ I. Preliminary. § II. Rules of the Royal National Life Boat Institution for the Management of Boats in a Surf. § III. Notes on the Management of Boats in a Surf.

CHAPTER XI.

GROUND TACKLE.

§ I. Anchors. Types of Anchors.—Old-fashioned and Patent Anchors.—Advantages and Disadvantages of Different Types.—Double-

fluked Anchor with a Stock. § II. Chain Cables. Details of Cables.—Manufacture of Cables. § III. Capstans, Windlasses, &c. Capstans.—Fittings used with Old-fashioned Capstans.—Windlasses.—U. S. Naval Windlass.—Letting-go an Anchor. § IV. Riding at Single Anchor. Advantages of a Long Scope.—Dragging. § V. Mooring. Advantages and Disadvantages of Mooring.—Clear and Foul Hawse.—To Clear Hawse.—The Mooring Swivel.—To Put on the Swivel.—To Take off the Swivel.—Weighing.—Stowing Anchors.—Catting and Fishing in One.—The Cat and Ground Chain.—Foul Anchor.

CHAPTER XII.

CARRYING OUT ANCHORS.

§ I. Various Methods of Carrying Out Anchors by Boats. § II. Carrying Out a Cable or Hawser. § III. Tables. Weights of Anchors.—Weights of Cables.—Weights of Hawsers.—Floating Power of Casks and Boats.

CHAPTER XIII.

THE STEERING OF STEAMERS.

§ I. The Elements entering into the Steering of Steamers. The Rudder.—The Screw Current.—Analysis of the Screw Current and its Effects.—The Sidewise Pressure of the Screw Blades.—The Wake Current. § II. Ship and Screw Going Ahead. The Turning of Ships.—The Turning Circle. § III. Ship and Screw Going Astern. Effects of Rudder and Screw Currents. § IV. Ship Going Ahead, Screw Backing. Forces Involved and their Effects.—Behavior of the Ship under Various Conditions. § V. Ship Going Astern, Screw Going Ahead. Forces Involved and their Effects. §VI. To Turn in a Limited Space. § VII. Twin Screws. Advantages of Twin Screws.—Turning of Twin-Screw Ships under different Conditions. § VIII. Additional Notes upon Steering. Effect of Wind.—Effect of Sea.—Effect of Shallow Water.—Heeling of Ships in Turning.—Importance of Knowing the Manœuvring Power of Ships.

CHAPTER XIV.

THE RULES OF THE ROAD.

§ I. International Rules, with Notes. § II. Rules for Inland Waters of the United States, with Notes. § III. Inland Rules of Nations other than the United States. § IV. Laws Relating to the Rules of the Road.

CHAPTER XV.

MANŒUVRING TO AVOID COLLISION.

§ I. Preliminary. § II. Steamers Meeting. § III. Steamers Crossing. Relative Speeds of the two Vessels as Affecting the Point of Meet-

ing. § IV. Steamers Crossing (continued). Discussion of the Manœuvres proper for Avoiding Collision (with diagrams).—Manœuvre for Giving-way Ship.—Manœuvre for Holding-on Ship.—A Steamer and a Sailing Vessel. § V. In a Fog. General Discussion.—Manœuvres proper under various Conditions. § VI. Speed in a Fog. The Law as to Moderate Speed.—Reasonableness of the Law.—Fallacy of the Arguments in Favor of High Speed.

CHAPTER XVI.

PILOTING.

§ I. Fixing the Ship's Position. The Chart.—Bearings.—Danger Angle.—Distance of an Object in the Horizon.—Distance of an Object by Two Bearings.—Bow and Beam Bearings. § II. Currents. Danger due to Currents.—Tidal Currents.—Slack Water distinguished from High and Low.—Effect of Local Conditions upon Tidal Currents. § III. Navigating in a Fog. Speed in a Fog.—Navigating by Soundings.—Use of Sounding Machine. § IV. Buoyage. General Rules as to Buoyage.—Buoyage of United States Waters.

CHAPTER XVII.

HANDLING A STEAMER ALONGSIDE A DOCK.

§ I. Preliminary. The Effects of Lines, Helm and Currents.—The Effect of a "Spring."—Advantages of Twin Screws. § II. Practical Cases. Handling Steamers without Tugs.—Putting a Right-handed Screw Vessel Alongside under Various Conditions.—Head Tide.—Fair Tide.—Working into a Restricted Berth. § III. Working into a Slip. Use of a Spring.—Use of the Helm.—A Head Tide.—A Fair Tide.—Hauling into a Dry Dock.—To Wind a Steamer at a Dock.—To Wind a Steamer in Making a Landing.—Getting Clear of a Dock. § IV. Handling a Large Vessel with the Aid of Tugs. Docking of a Large Ocean Liner at New York.—Undocking.

CHAPTER XVIII.

PLACING A SHIP IN DRY DOCK.

The Docking Plan.—Fittings of a Dock.—Preparations for Docking.—Floating the Vessel in.—Pumping out the Dock and Securing the Ship.—Precautions.—Inspection of Underwater Hull.—Flooding the Dock and Floating the Ship.

CHAPTER XIX.

WEATHER AND THE LAWS OF STORMS.

§ I. Weather, Winds, Clouds and Rainfall. Weather Maps of the World for January and July.—Isobars.—Highs and Lows.—Cyclones and Anti-cyclones.—Weather of Cyclones and Anti-cyclones.—Velocity

of Wind dependent upon Barometric Gradient.—Moisture and Precipitation.—General Wind Circulation.—Explanation of the Motion of Rotation in Cyclones and Anti-cyclones.—Buys-Ballots Law.—Trade Winds. —Westerlies.—General Eastward movement of the Atmosphere in High Latitudes.—Weather Changes and Weather Prediction.—Weather Maps of the United States.—Temperature Changes.—Precipitation.—Monsoons.—Land and Sea Breezes.—The Barometer.—Clouds. § II. The Law of Storms. The Origin of Tropical Hurricanes.—Air and Cloud-Circulation in a Hurricane.—Motion of Rotation.—Motion of Translation.—Chart Illustrating the Progress of a Hurricane.—Shifts of Wind.—The Storm Wave.—Indications of an Approaching Hurricane.—Rules for Manœuvring in a Hurricane.—Difference between a Steamer and a Sailing Vessel.

CHAPTER XX.

HANDLING STEAMERS IN HEAVY WEATHER.

§ I. Lying-to. Lying-to with Sea on the Bow.—Objections to the Preceding Method in a Modern Steamer.—Drag of the Propeller.—Lying-to with Engines Stopped.—Running Slow before the Sea.—Rolling of a Ship in Waves.—Relation between the Period of the Ship and that of the Sea.—Importance of Breaking up Synchronism between Periods of the Ship and the Waves.—Bringing a Steamer up Head to Sea and Holding her there.—Sea-Anchors.—Anchors for Large Ships.—Riding Out a Gale at Anchor. § II. The Use of Oil. Advantages of Oil.—Method of Using under different Conditions. § III. Opinions of Shipmasters upon Lying-to in Modern Steamers.

CHAPTER XXI.

TOWING.

§I. The Towline. Should be Long and Heavy.—Chain-cable.—Wire-rope.—Manila and Coir.—Advantage of Keeping Ships "In Step."—Securing the Line on the Towing Vessel.—Securing the Line on the Tow. § II. Towing in Smooth Water. Tow-rope Resistances.—Starting a Tow. § III. Taking a Disabled Vessel in Tow at Sea. Importance of considering the Drift of the Vessels.—Most favorable Positions for Running Lines.—Use of a Boat.—Use of a Float.—Code of Signals.—Rocket Gun.—Running Lines.—Casting Off. § IV. Towing Engines. Towing Alongside. Advantages of Towing Engines.—Use of Wire-rope with Towing Engines.—Towing Alongside.—Making fast Alongside.

CHAPTER XXII.

RESCUING THE CREW OF A WRECK.

Manœuvring.—Lowering the Boat.—Communication between the Boat and the Wreck.—Danger of Going Alongside to Leeward.—Dropping Down with a Line.—The Use of Oil.—Signals.—If a Boat Cannot be Lowered.—Letter from Captain Doxrud of "Noordland."

CHAPTER XXIII.

MAN OVERBOARD.

Danger that Man will be Struck by Screw.—Engines should be Stopped at Once.—Lookout from Aloft.—Life-buoys.—Importance of having a good Marker.—Use of a Light for a Marker.—Manœuvring to Pick up the Man.—Stopping and Backing.—Turning the Ship.—In Case of Fog.

CHAPTER XXIV.

STRANDING.

§ I. Backing or Pulling off. Possible Danger of Backing Immediately.—Precautions to be Taken.—Sounding.—Laying Out Anchors.—Tidal Currents.—Lightening Ship.—Assisted by another Vessel.—If Assisting Vessel cannot Anchor.—If Beach is Steep and not Rocky. § II. Instructions to Mariners in Case of Shipwreck, from Publications of the Life-Saving Service. Rescue with the Surf-boat.—Rescue with the Breeches-Buoy or Life-Car.—Receiving and Securing the Shot-line and Hawser.—Signals between Ship and Beach.

CHAPTER XXV.

MAKING AND TAKING IN SAIL.

Remarks upon Handling Sails.—Setting and Taking in Sail under Different Conditions.—Reefing Topsails.—Stun'sails.—Bending Sail.

CHAPTER XXVI.

MANŒUVRING UNDER SAIL.

§ I. Preliminary. The Forces Involved in Manœuvring Under Sail. § II. Tacking, Wearing and Boxhauling. General description of Manœuvres.—Tacking.—Wearing.—Boxhauling. § III. Variations of the Preceding Manœuvres. Missing Stays.—Boxing Off onto Old Tack.—Backing Around onto New Tack.—Wind out on the Lee Bow.—Chapelling Ship.—To Heave To.—Man Overboard.—Bracing Yards.—In a Gale.—Lying-to.—Sea-Anchor.

CHAPTER XXVII.

GETTING UNDERWAY AND COMING TO ANCHOR UNDER SAIL.

§ I. Getting Underway. Casting.—Making Sail.—Weighing.—To Weigh and Stand Out on the Wind.—In Case of Danger Astern. § II. Shortening Sail and Anchoring. Difficulty of Coming to Anchor at a Definite Spot.—Precautions.—To Stand in on a Wind and Anchor.

CHAPTER I.

THE HULL AND FITTINGS OF A SHIP.

The size, form, speed, power, armor, armament and rig of a ship depend upon the nature of the services she is expected to perform. Whatever her design may be, she must have ample stability, strength, habitability, and a complete outfit of all appliances, fixed and portable, necessary to ensure her efficiency under all service conditions.

The principal types of ships are:

BATTLESHIPS, usually having displacements greater than ten thousand tons, great beam in proportion to length, moderate speed and power, heavy armor at water-line and on turrets with lighter armor elsewhere, heavy guns mounted in turrets or barbettes, lighter guns in broadside, and small guns mounted wherever space will permit; and one or two military masts.

ARMORED CRUISERS, having displacements greater than eight thousand tons, high speed, great power, moderate armor on turrets and barbettes, light armor at and above the water-line, a protective deck, large coal capacity, numerous guns, and one or more military masts.

PROTECTED CRUISERS, having displacements greater than three thousand tons, good speed, no armor except on turrets, barbettes, or sponsons, a protective deck, varying coal capacity, numerous guns, and one or more military masts, or masts fitted for carrying steadying sails.

GUNBOATS, having displacements less than two thousand tons, fair speed, good coal capacity, no armor or protective deck, moderate battery, and generally provided with moderate sail power.

TORPEDO BOATS AND DESTROYERS, having displacements less than five hundred tons, extremely high speed, poor coal capacity, no armor, very fragile hull, with one or two signal poles.

MONITORS, with one or two heavily armored turrets carrying high-powered guns, very low freeboard with heavily armored sides, an armored deck, poor coal capacity, low speed, and one military mast.

Merchant ships for passenger or freight service, of all sizes and speeds, no armor or protective deck, large coal capacity, masts for steadying sail or cargo booms, and usually provided with large double bottoms for carrying water ballast when it is needed.

Sailing ships, of wood or steel, used for training or trading purposes, with numerous varieties of rig and many special fittings adapted to the particular service on which they are engaged.

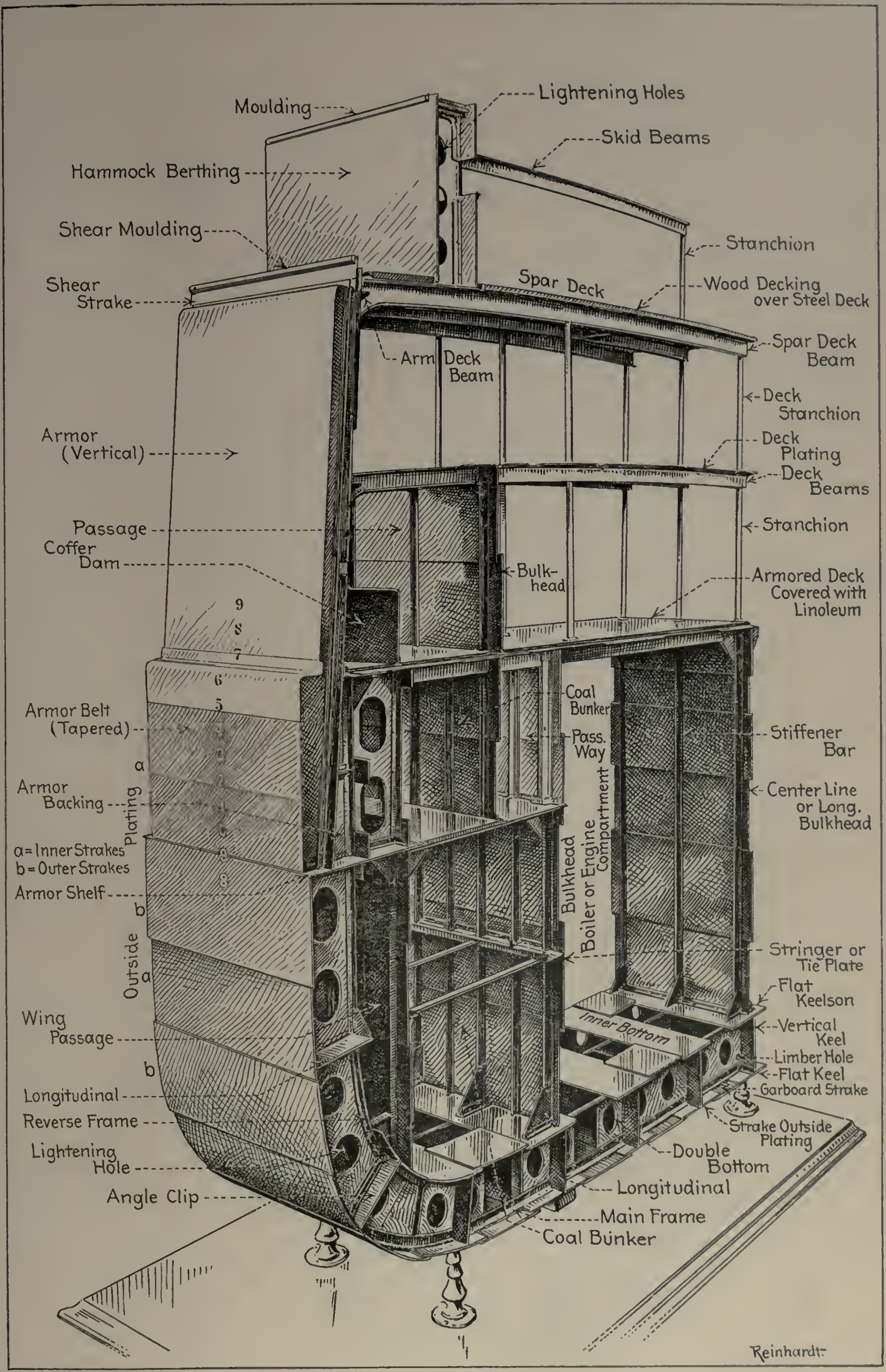
THE HULL: The principal parts of the hull of a modern ship are named below, and the locations of many of them are shown on Plates **1**, **2** and **3**. These are views of the midship section, bow and stern of a steel battleship.

The keel is usually composed of the outer and inner keel plates, the vertical keel and the main keelson, with their accompanying angle bars. In some merchantmen a vertical outside keel is fitted; and on composite and sheathed ships the keel plates carry wooden keels and false keels. At its forward end the keel is continued by the stem, which is of great strength, and at its after end by the stern-post, also very strong and arranged to carry the propellers and rudder.

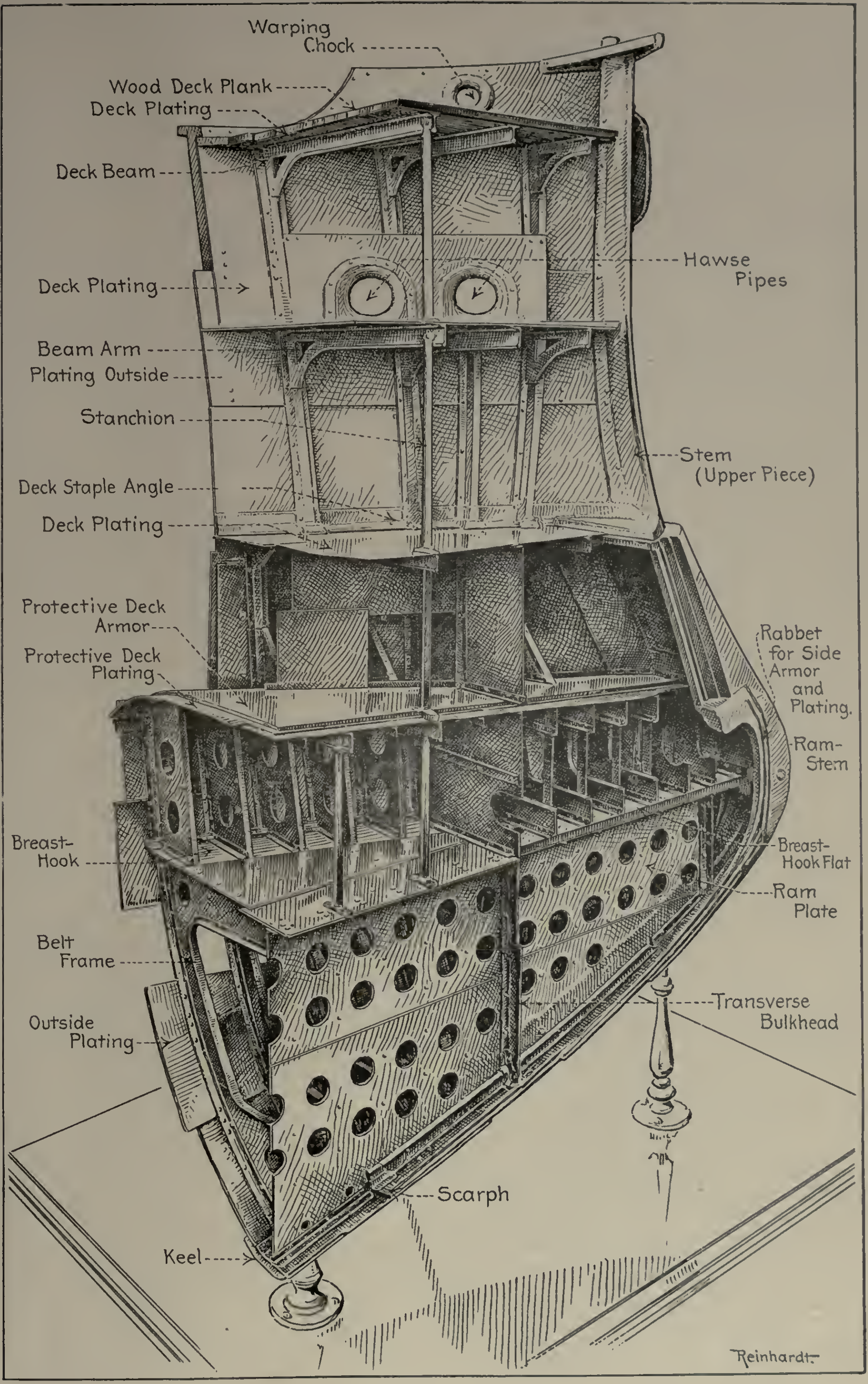
To the keel are attached the frames, built up of main bars, floor plates and reverse bars, all of which are strengthened and stiffened by longitudinals of various types. To these, the outside plating is secured, the garboard strakes being adjacent to the keel plates. An inner bottom is fitted on large ships; this extends to the armor shelf on battleships and monitors, and to the shelf plates on other vessels. The double bottom extends fore and aft to a greater or less degree from the midship section, depending upon the particular type of ship; it is subdivided into small cells by water-tight frames and longitudinals, so that leakage shall be reduced to a minimum if the ship touches bottom. The frames near bow and stern are spaced more closely than elsewhere to provide local strength, and breast hooks, ram plates, transoms, and counters are fitted for like reasons.

Sheathed ships are fitted with outside plating to which is fastened outside wood planking below the water-line; **composite**

Plate No. 1.

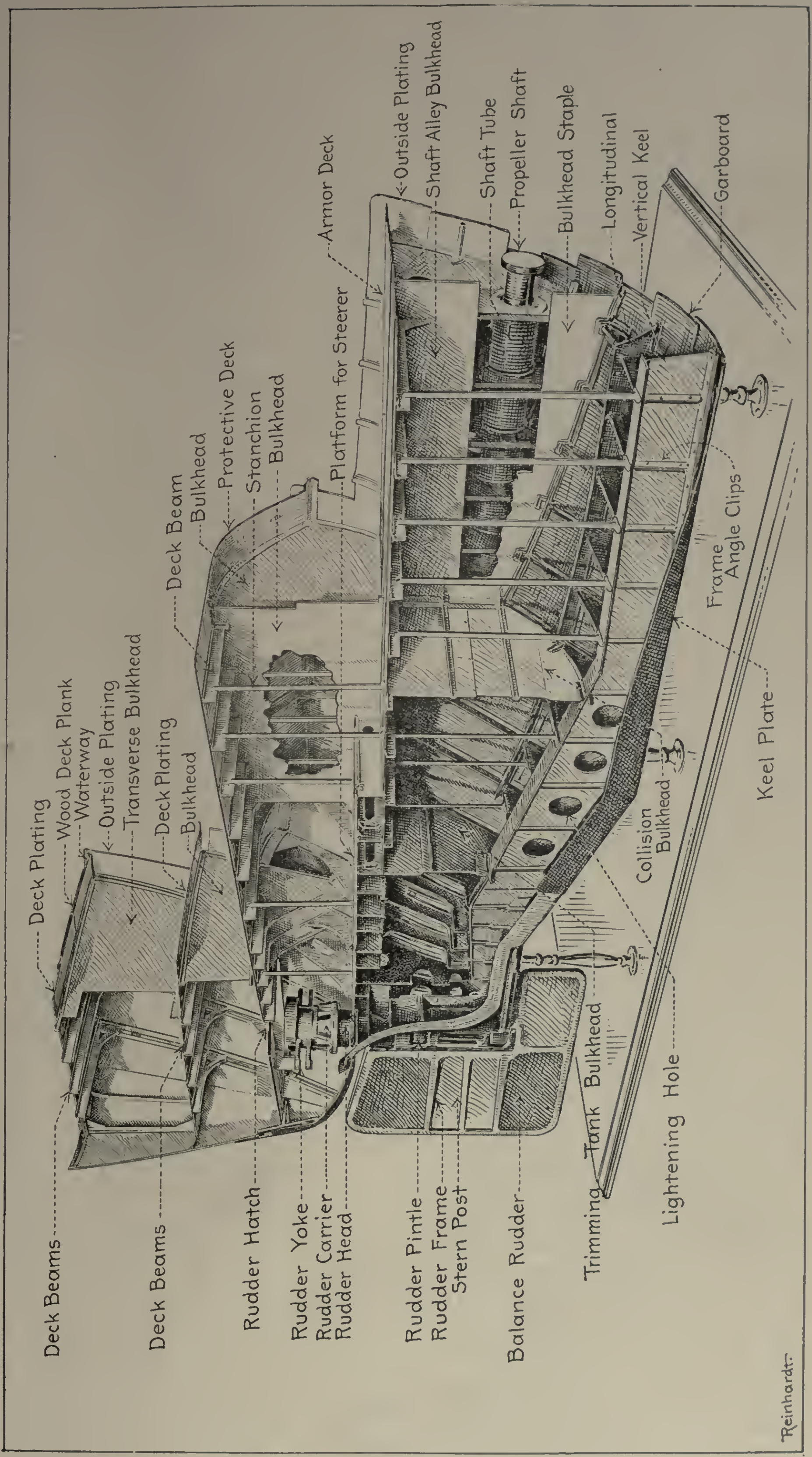


Midship Section of a Battleship



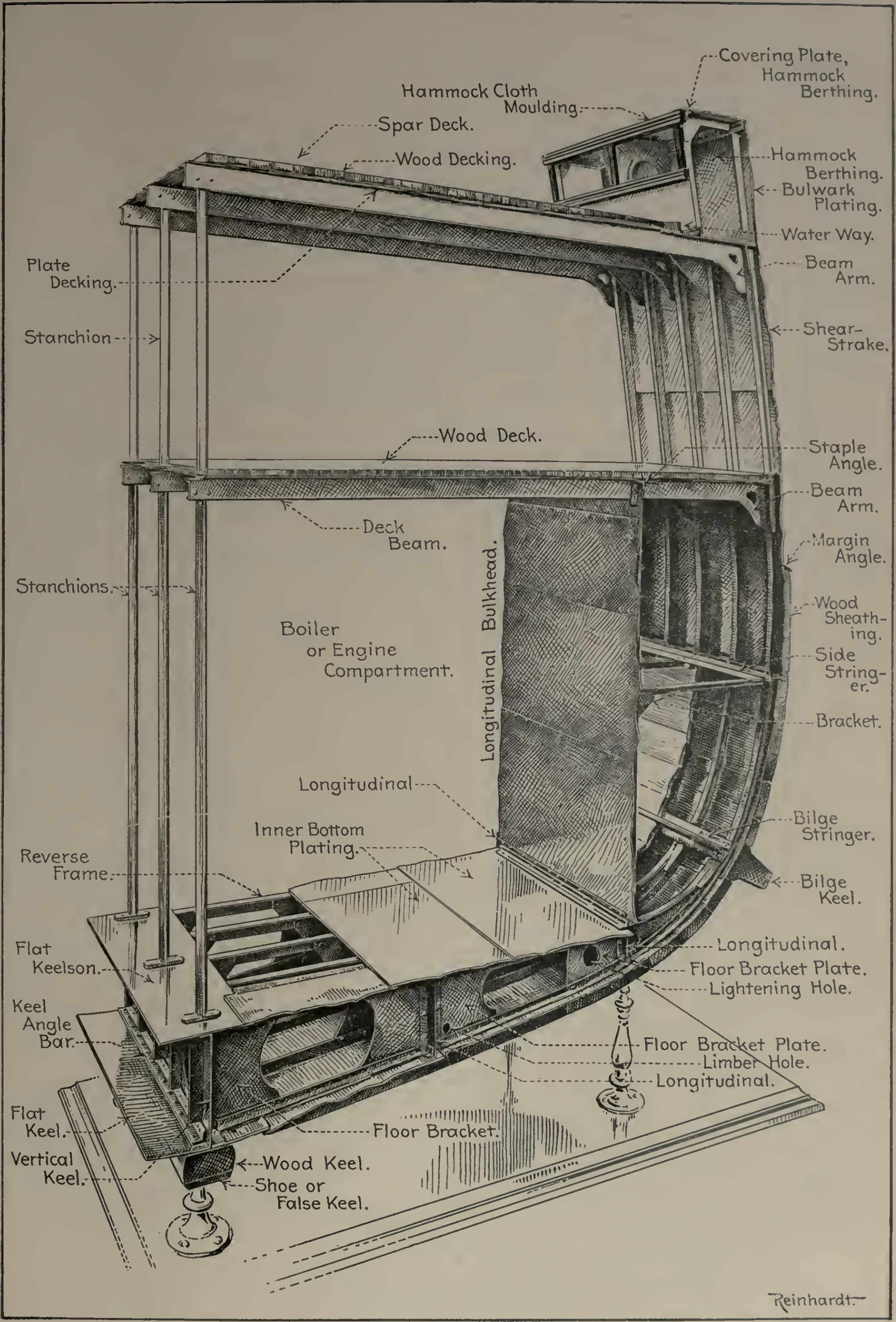
BOW OF A BATTLESHIP.

Plate No. 3.



STERN OF A BATTLESHIP.

Plate No. 4.



MIDSHIP SECTION OF
1200-TON GUNBOAT (SHEATHED.)

ships have no outside plating but have wood planking which is fastened to the frames; in both cases this planking is coppered to lessen fouling, great precautions being taken to prevent injury to the steel hull from galvanic action.

Bulkheads are used to vertically subdivide the ship's interior into water-tight compartments for the preservation of buoyancy and stability; non-water-tight bulkheads are also fitted to provide stowage and living spaces.

Decks are primarily used to provide shelter, working spaces and living quarters; secondarily, to horizontally subdivide the hull into a still greater number of water-tight compartments. Those used for the latter purpose are of steel, and may or may not be covered with planking or linoleum. Other decks are planked and calked only, but deck stringers and tie plates are used to stiffen the deck beams, which are also supported by stanchions in addition to the bulkheads. All of these are absolutely necessary to ensure the ship's structural strength. To secure accessibility to all parts of the ship, numerous hatches, doors, scuttles and man-holes are provided; these are water-tight where necessary, and are always fitted for battening down on upper decks.

Warships are provided with protective decks of steel, to protect the propelling machinery and other objects below the water-line; even on gunboats it is not uncommon to find a steel water-tight deck, which assists in preventing loss of stability if the outside plating should be penetrated near the water-line.

STEERING GEAR: The rudder of a warship is unusually large and the steering gear unusually strong, in order that such a vessel may be under more perfect control than is considered necessary in merchantmen; and in the later designs of warships the after deadwood is cut away and the rudder partially balanced to still further increase the manœuvring qualities. The rudder is arranged so that it can be unshipped in dry dock. The rudder stock is usually made of the best hammered scrap iron, its size depending upon the speed and size of the ship and the rapidity with which it is necessary to put the helm hard over when the ship is at her maximum speed. The rudder frame is usually of cast steel, which is filled in with wood and covered with steel plating. On most ships, the weight of the rudder is taken on a suitable carrier within the ship, firmly supported by the hull structure and so arranged that the stuffing box and gland attached to the rudder-post casting may be accessible, as shown on Plate **5**. With sheathed or composite ships, copper alloys are used instead of steel for rudder post and rudder.

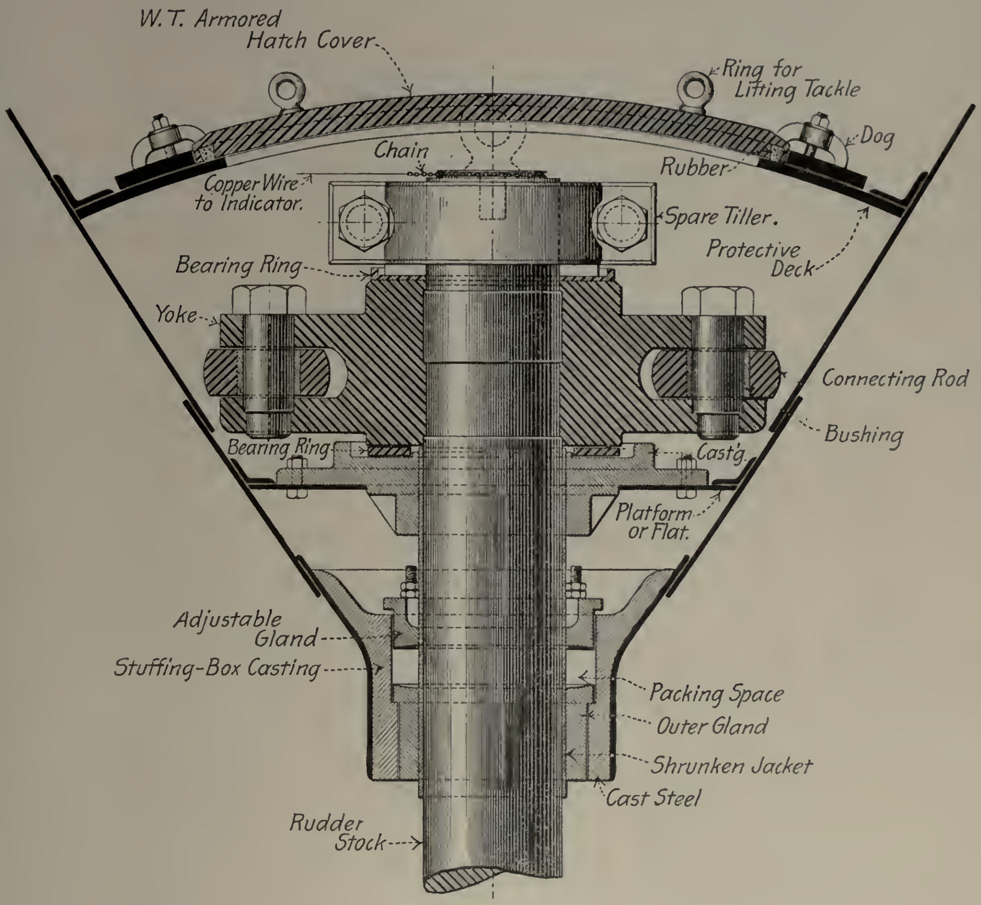
To the rudder head, the rudder cross-head or the tiller is firmly secured. Sometimes both are fitted as shown on Plate **6**. It frequently occurs that the run of the ship is so fine that it is necessary to fit a secondary cross-head placed further forward in order to provide space for the steering gear and its connections, the two cross-heads being connected by suitable rods. It is not uncommon, where space permits, to use a straight tiller or quadrant which is connected to the steering mechanism by chain or wire rope. The rudder is thus turned through an angle of about 35 degrees on each side of the center line, hard-over stops being fitted to the rudder post and the rudder frame to limit the amount of travel should accidents occur to the steering mechanism. The motive power is usually steam or hydraulic, hand power being always provided for use in cases of complete break down. The application of air and electricity is still in the experimental stage.

Where a rudder cross-head is used (Plate **6**), the steam engine turns a shaft having a right and left-handed thread which drives two nuts connected to the cross-head by side rods. By turning the engine in one direction the nuts recede from each other and the cross-head turns in one direction, and by turning the engine in the reverse direction, the nuts approach each other and the cross-head is turned in the reverse direction. When hydraulic power is used, the side rod from each side of the cross-head connects with a suitably guided piston rod, having a piston within a cylinder, each end of which permits the entrance of water at high pressure, and also its exhaust. By admitting water at the forward end of one cylinder and the after end of the other while at the same time opening the exhausts at the opposite ends, the cross-head is turned in one direction, and will be turned in the opposite direction by reversing the operation.

With quadrants and tillers, the chain or wire rope is wound around a drum which can be turned in either direction, suitable provisions being made to prevent any slack occurring.

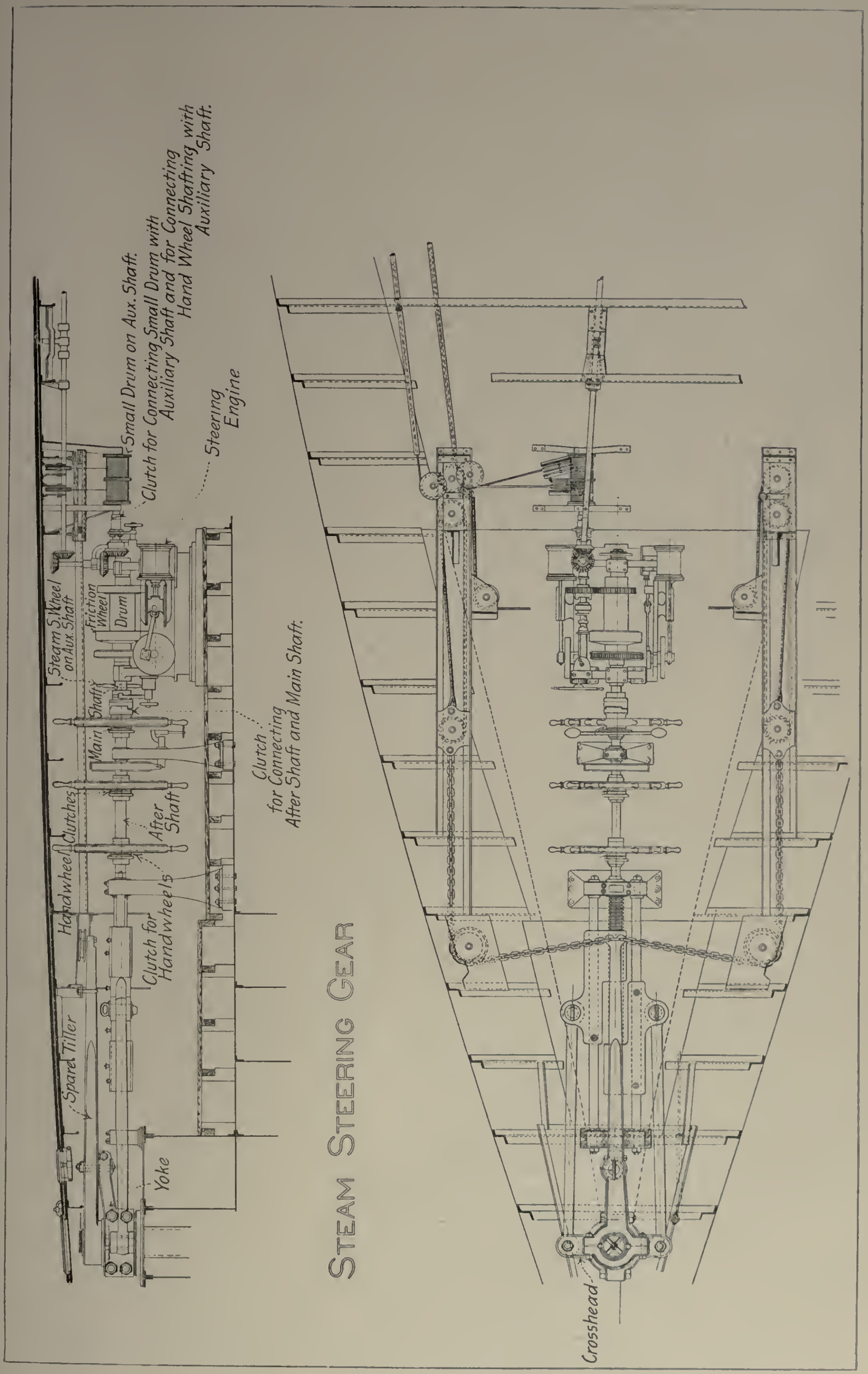
The hand gear consists of steering wheels of large size located in various parts of the ship, which by shafting, chain, or wire rope, operate the rudder in the manner shown on the plans.

Plate No. 5.



SECTION THROUGH RUDDER STOCK

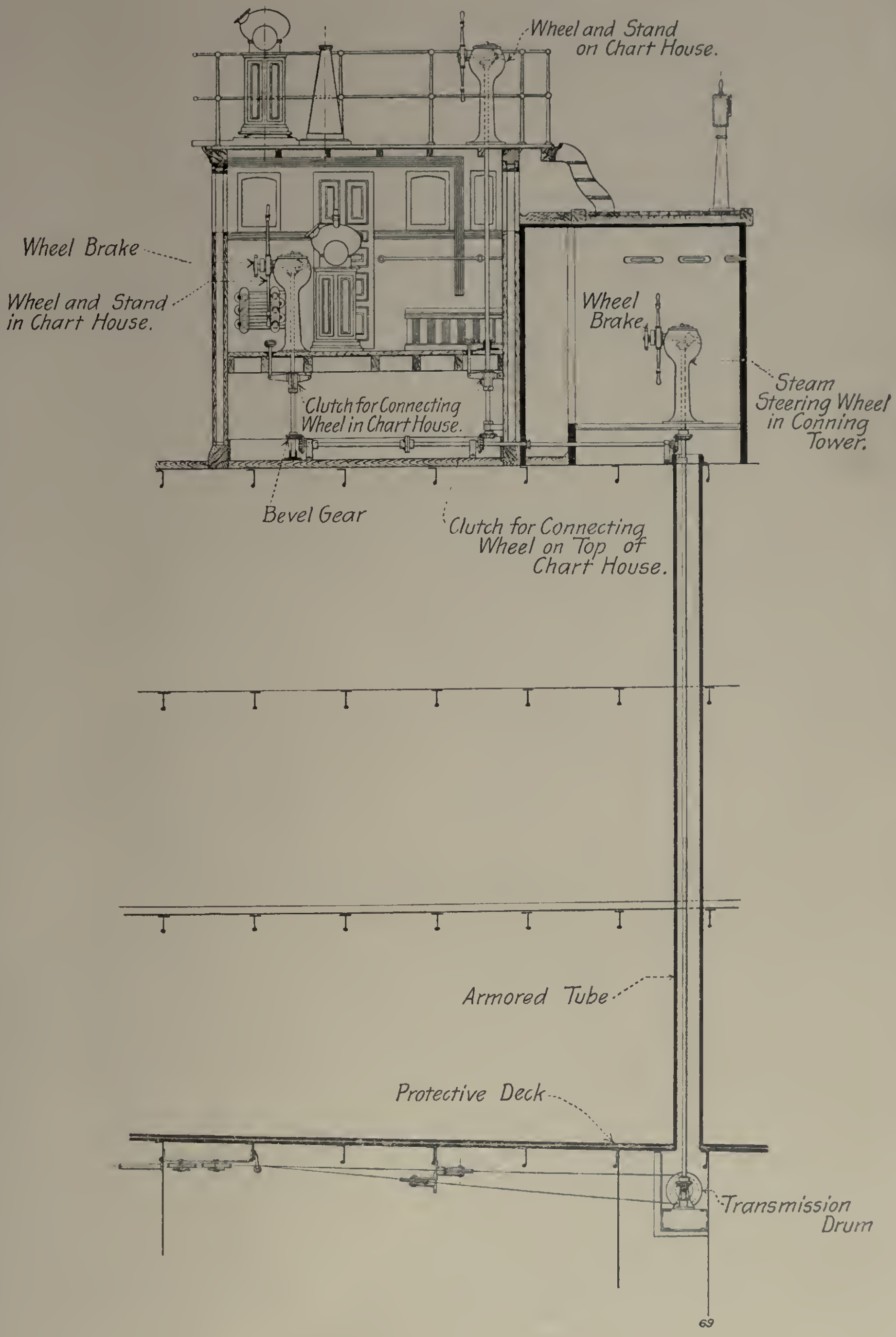
Plate No. 6.



STEAM STEERING GEAR

Small Drum on Aux. Shaft.
Clutch for Connecting Small Drum with Auxiliary Shaft and for Connecting Hand Wheel Shafting with Auxiliary Shaft.
Steering Engine
Steam S. Wheel on Aux. Shaft
Friction Wheel
Drum
Shaft
Main Shaft
Clutch for Connecting After Shaft and Main Shaft.
Clutches
After Shaft
Handwheel
Handwheels
Clutch for Handwheels
Spare Tiller
Yoke
Crosshead

Plate No. 7.


Wheel and Stand on Chart House.
Wheel Brake
Wheel and Stand in Chart House.
Wheel Brake
Steam Steering Wheel in Conning Tower.
Clutch for Connecting Wheel in Chart House.
Bevel Gear
Clutch for Connecting Wheel on Top of Chart House.
Armored Tube
Protective Deck
Transmission Drum
69

Hand Steering Gear in Chart House
and
Conning Tower of a Cruiser

Power steering wheels are usually provided (Plates **7** and **23**) in the conning-tower, in the chart house, and on the bridge; and where practicable are arranged with clutches so that any one wheel can be turned without turning the others. From the conning-tower stand, a steel rod extends downwards through the armored tube and below the protective deck, where it rotates a transmission drum, which in turn rotates a second drum located in the steering room, the two being connected by the steering rope. The valve controlling the admission and exhaust of steam or water is automatically operated by the transmission drum so that the rudder is turned whenever the helmsman turns the power steering wheel, and remains stationary at any angle when the wheel is kept stationary at the corresponding position, the helm indicator showing at each instant the actual position of the helm. Various electric and hydraulic appliances are also used to accomplish these same purposes.

VENTILATION is provided to secure a circulation of air within the hull's interior and to replace foul air by fresh air taken from the outside atmosphere. Natural ventilation is provided by cowls and windsails, which, when trimmed to the wind, send fresh air below to replace foul air which is forced outboard through hatches, air-ports, etc., or through exhaust cowls which are trimmed from the wind to increase the rapidity of air circulation. Artificial ventilation is provided by steam or electric blowers, which drive fresh air from outboard and discharge it through ducts and louvres into the ship's interior; or which draw foul air from the interior and discharge it outboard. In large ships, both of these artificial systems are frequently combined; one set of blowers supplying fresh air, and another set exhausting foul air. In all ships, natural ventilation is extensively provided, and careful attention to apparently small details is necessary to secure efficient circulation. A sample system is shown on Plate **8**.

DRAINAGE: To provide for the removal of large quantities of water from the bilges, the main circulating pumps are provided with bilge suctions and are also usually connected to a main drain pipe of large size which generally extends from the forward fire-room bulkhead to the after engine-room bulkhead, with suitable valves permitting the inlet of water from any main compartment which is to be drained. There is also a secondary drain connected to numerous pumps, which enables small quantities of water to be removed from any compartment in the following manner: A metal chest called a *manifold*, containing a number of suitable valves, is located in a convenient position. One of these valves is connected by piping to an adjacent pump, another to the secondary drain, another to the sea, and each one of the remainder to some particular compartment above or within the double bottoms. To remove water from any compartment containing water, it is only necessary to open the valve connecting with that particular drainage pipe and the valve connecting with the adjacent pump, and then to operate the pump. In case the pump is not available for this purpose, the water can pass through the secondary drain to some other manifold whose pump is available. Thus, as shown on Plate 9, if it be desired to pump water overboard from compartment A-99, which is connected by a pipe with suction S to a manifold valve B, all the valves leading to other suction pipes are closed, also the valve C, connecting to the secondary drain; the suction valve D of the pump X is opened and all others closed, the discharge overboard H, is opened, all other discharges closed, and the pump started, when it draws water directly from A-99 and sends it overboard. The water can be sent into the firemain by closing E, and opening F. The pump can be made to draw from the sea and discharge into the firemain by closing every suction except G, and every discharge except F. If it be desired to *admit* water into A-99, close C and all manifold valves except B, open H, and close G and D. Finally, if pump X is not available, pump Y can be readily used through manifold N, by opening C, closing D and H, opening C_2, G_2, and H_2, through which latter valve the water in A-99 can finally be discharged overboard. Many combinations of this type are provided, necessitating a complication of valves and piping in the bilges, but it is always necessary to ensure one set of valves being closed, and another opened in the manner outlined above.[1]

The Firemain (Plate 8) usually consists of a copper pipe running fore and aft nearly the whole length of the ship, and placed on warships underneath the protective deck. It is con-

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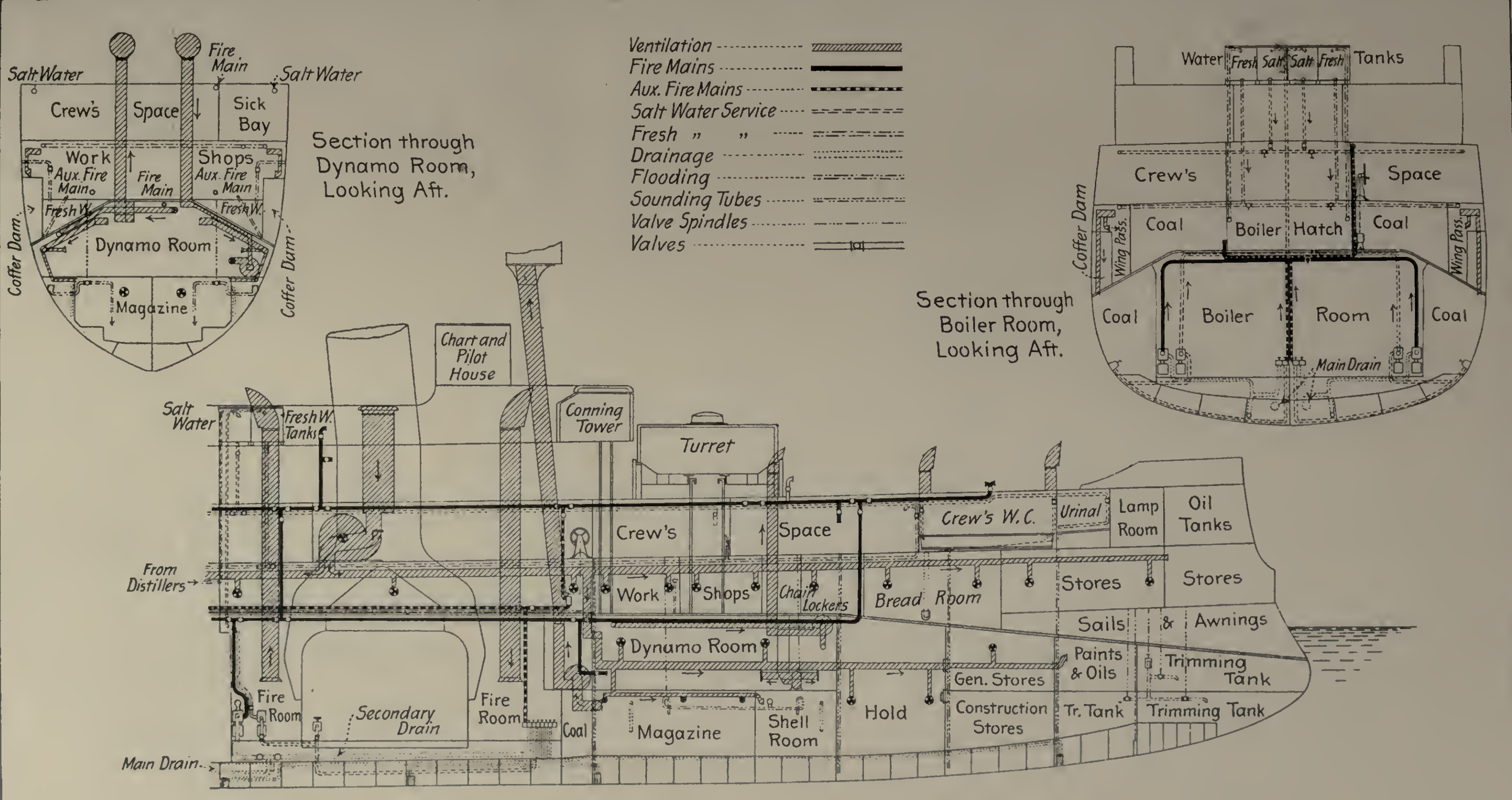
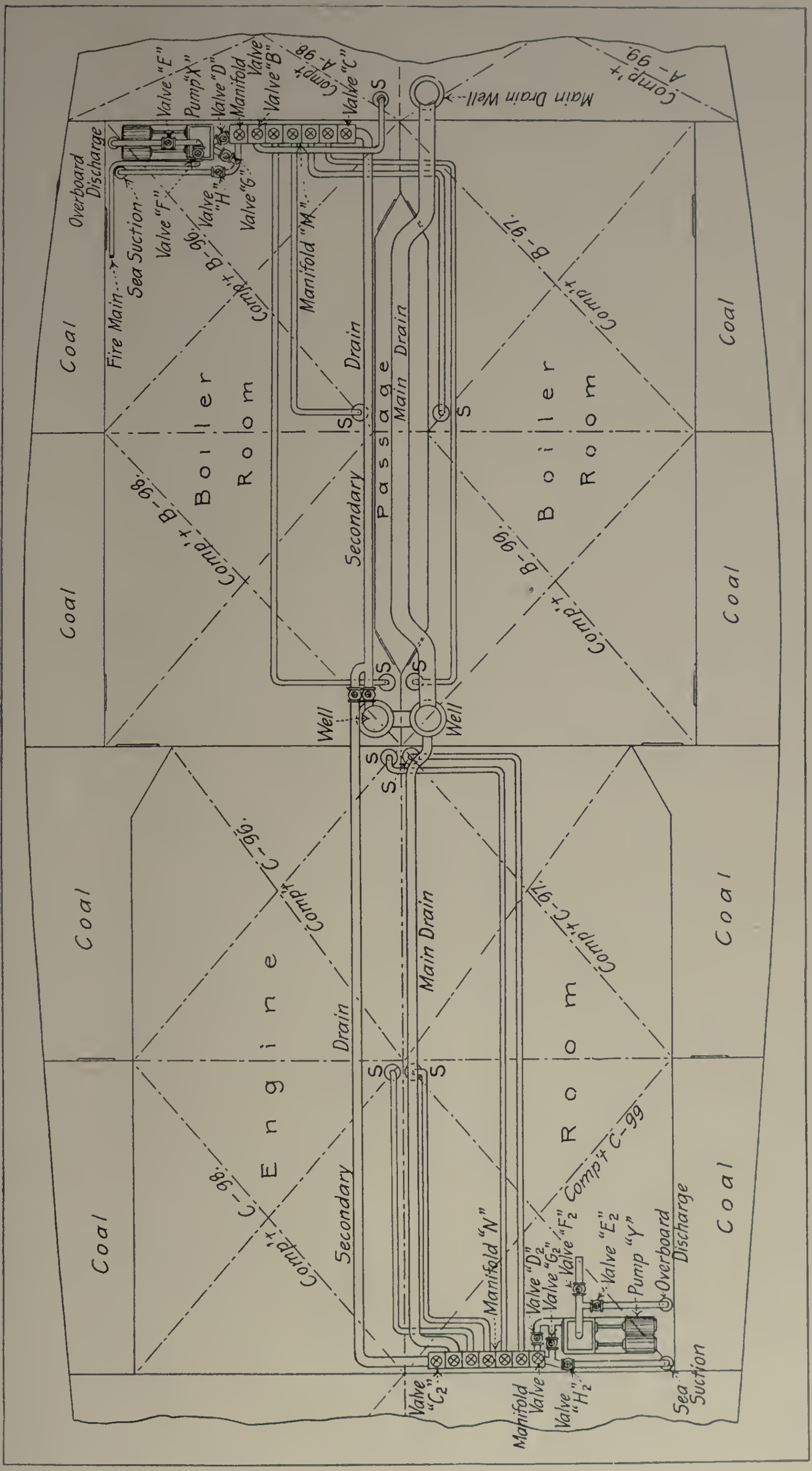
[1] The seemingly complicated table of valves to be opened and closed for draining a particular compartment is simply an enlargement of the above outline.

Plate No. 8.



Skeleton Piping and Ventilation Plan.

Plate No. 9.



SKELETON DRAINAGE PLAN SHOWING MANIFOLDS.

nected to almost all pumps, both steam and hand, which draw water from overboard, so that any or all of them can be used to maintain it full of water under pressure. Numerous branches are located in suitable positions on the various decks, to which are attached hose plugs to furnish water for fire and wash deck purposes. On recent warships the various upper outlets are connected by vertical branches to the firemain below the protective deck, each having a stop valve by which it may be cut off from the rest of the system; so that any one set of outlets may be disabled without disabling the others. Fire hose ready for instant use is stowed near each fire plug. Branches from the firemain are frequently led into the coal bunkers for use in extinguishing fires caused by spontaneous combustion. The salt water required for flushing the heads and lavatories is sometimes supplied from the firemain direct, and sometimes by a separate system of flushing pipes which are filled by certain special steam and hand pumps.

Fresh water is carried in steel tanks which can be filled from shore, from water boats, or from the ship's own distillers; from these main tanks, it is usually pumped to one or more distributing tanks from which it flows by gravity through pipes to the necessary outlets at scuttle butts, state rooms, pantries, and galleys; in many cases, however, small hand pumps are located in convenient places and connected directly to the main tanks.

Magazines usually are flooded, when necessary, through pipes connected to the sea; one or more flood cocks being provided in each ammunition room, so arranged that they can be opened from the handling space and also from an upper deck. They are so arranged that they can be securely locked, and are provided with indicators which show whether the flood cocks are shut or open. Air escapes leading to upper decks are provided, to let the magazines fill rapidly, overflow valves to prevent too great pressure upon the deck covering the magazines, and drain valves to permit the water to flow out when it is no longer needed. In large warships, a valve connected to the firemain is located in large ammunition rooms not greatly below the water-line, to ensure rapid flooding.

WATER-TIGHTNESS: The plates of the outer skin, bulkheads, and decks which are meant to be water-tight, are fastened by rivets, and the seams and butts are calked metal to metal; the planking of weather decks and of other wooden decks liable to be wet down, is made water-tight by filling the seams and butts with oakum or cotton, which is driven down thread by thread and afterwards covered with glue, putty, or pitch. Air-ports, gun-ports, coaling-ports, and similar openings in the outside plating above the water-line, are closed tightly by compressing rubber on suitable frames, using dogs, clamps, turn-buckles, &c. The openings in water-tight bulkheads and decks necessary for communication, are provided with water-tight doors, hatches, and man-holes; the two latter are usually made water-tight by compressing rubber with dogs and clamps, but the rubber is omitted in locations where wear is to be expected and some slight leakage will be of small consequence. Water-tight doors, however, are of such importance that special types are used; the hinged door in important bulkheads is made tight by rubber and clamping dogs, but the doors in the principal bulkheads which must necessarily remain open under ordinary service condition are usually arranged to slide, either vertically or horizontally, and become tight by wedging together two metal surfaces; this operation being performed at the door or at a distance from it, by various methods. The appliances for securing water-tightness vary greatly on different ships, *but the necessity for keeping all of them in efficient condition is of the highest importance;* if they are inefficient during an emergency, the elaborate subdivisions of the hull's interior into water-tight compartments may become worse than useless.

MISCELLANEOUS: There are numerous fittings attached to the hull which cannot be described in detail, but whose presence is essential. Some of the principal minor fittings are:

Mooring staples, attached to the outside of the hull, to which can be attached mooring chains or lines.

Portable davits and derricks, for hoisting boats, coal, and cargo, when the ship is in port, but which can be readily removed at sea.

Winches, fitted with drums and gypseys, for hoisting boats and cargo, handling anchors, and aiding the crew in handling lines.

Bitts, secured to various parts of the deck, with warping chocks or fair-leaders in their vicinity.

Pin-rails, fife-rails, belaying-pins, cleats, eye-bolts, and chain-bolts, are necessary for handling running gear.

CHAPTER II.

ROPE—KNOTTING AND SPLICING.

§ I. ROPE.

The rope commonly used on ship-board is of three kinds: Hemp, tarred and untarred, Manila and Wire. Coir is sometimes used for heavy tow-ropes, for which it is particularly well adapted. Ropes are made also of flax and cotton, but these are not suitable for use at sea.

Much confusion results from the common practice of designating all ropes made from vegetable fibre, as "hemp." This mistake is almost universally made by other than sea-faring people in referring to manila; which is sometimes called "manila hemp," but oftener simply "hemp." Hemp rope is made from the fibre of the hemp plant, which is cultivated extensively in many parts of the world, but especially in Italy, Russia and the United States. Russian hemp is very generally used for cordage, Italian hemp for packing, and American hemp for small stuffs.

Manila rope is made from the fibre of the wild banana and comes principally from the Philippine Archipelago.

Coir is made from the fibre of cocoanut husks. As it is very buoyant and does not become water-logged, it has a great advantage over hemp, manila, and wire, for tow-ropes.

In the manufacture of rope from the original fibres these are twisted together into threads or yarns, which in turn are twisted into strands. A number of strands are laid up into a rope, and sometimes several ropes are combined to form a cable. (Plate **10**.)

The twisting which is necessary in these various processes weakens the rope very materially; at least one-third of the original strength of the fibres being lost. On the other hand, the twisting adds considerably to the elasticity of the rope.

To counteract the tendency to unlay, the successive twists are taken in opposite directions; yarns being usually right-handed, strands left-handed, ropes right-handed, and cables left-handed. The above rule may be reversed, producing "left-handed" or "back-handed" rope.

Rope is commonly made with three strands, but four are sometimes used. In this case, the strands are laid up around a "heart" which fills the space that would otherwise be left within the rope. The rope thus produced is called four-stranded or "shroud-laid" rope.

Hemp rope as at present used is almost invariably tarred. In this form it is used for such of the standing rigging as is not of wire, and for the heaviest of the running rigging;—such as lifts, tacks and sheets of courses, topsail sheets, etc. The tar preserves the rope from deterioration due to the dampness, but reduces its strength and flexibility. Hemp when not tarred is known as "white-rope" and is the strongest rope used except wire.

Manila is used for most of the running gear, for reeving off purchases, and for the greater part of the miscellaneous work of the ship. It is somewhat weaker than untarred hemp, but does not deteriorate so rapidly from moisture.

Both the manila and the hemp rope of commerce vary greatly in quality. At their best, both should show a smooth, even surface when laid up, with few projecting ends of the fibres. When unlaid, the strands should show long and glossy, without admixture of short ends or "tow."

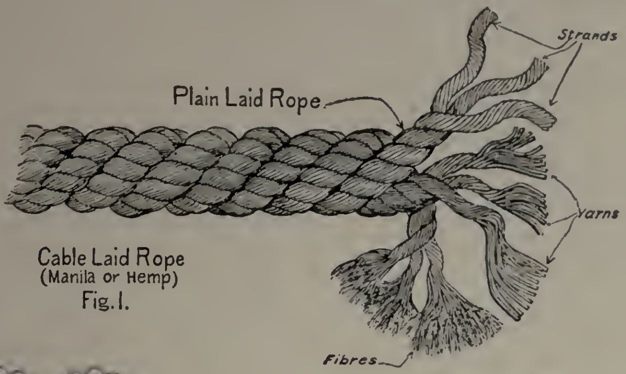
The strength of a rope-yarn varies from 75 to 100 lbs.

For special purposes, rope is sometimes plaited instead of laid. This does away with the tendency to kink.

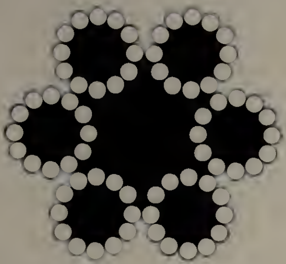
Rope is designated as to size by its circumference, and runs from about a half inch to sixteen inches and even more; but the largest sizes are never seen on ship-board, twelve inches in manila and six inches in wire being about the maximum that even the largest ship would carry. Its length is measured in fathoms.

Cordage smaller than a half inch is usually known on shipboard as "small-stuff," and designated either by the number of threads that it contains, as "18-thread stuff," "15-thread stuff," etc.;—or as "Ratline stuff," "Seizing stuff," "Marline," "Spun-yarn," etc. These are usually of American hemp, tarred, and are measured in some cases by the fathom, in other cases by the pound.

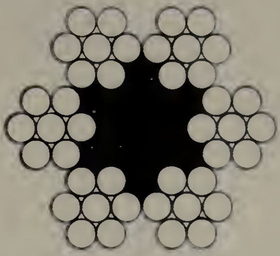
Plate No. 10.



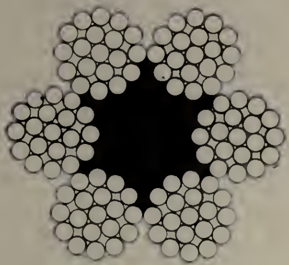
Cable Laid Rope
(Manila or Hemp)
Fig. 1.



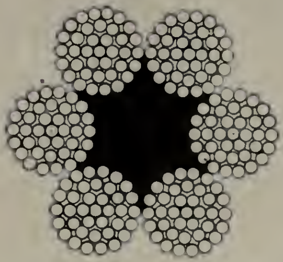
Running Rigging or Hawsers
(Type B. U.S. Navy)
Fig. 2.



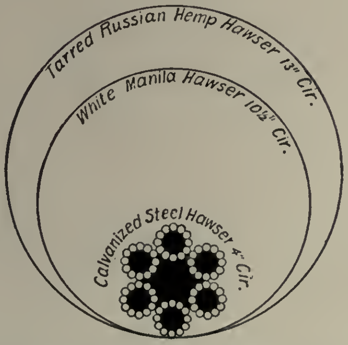
Transmission or Standing Ropes
Fig. 3.



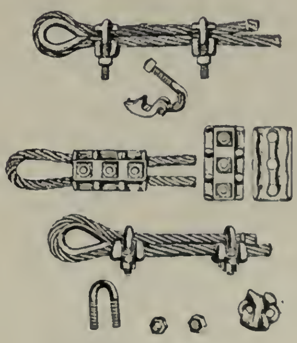
Flexible Hoisting Ropes
(Type A. U.S. Navy)
Fig. 4.



Special Type for Heavy Tow Lines
Fig. 5.


Tarred Russian Hemp Hawser 13" Cir.
White Manila Hawser 10½" Cir.
Galvanized Steel Hawser 4" Cir.

This Illustration shows the relative sizes of Hemp, Manila and Steel Ropes of equal strength. Fig. 6.



Clamps for Wire Rope
Fig. 7.

ROPES.

The following are the most common varieties of small-stuff used on shipboard.

Spun-yarn. A rough and comparatively cheap stuff made from long tow and loosely laid up, left-handed, of two, three or four strands. It is more used on shipboard than any other variety of small stuff, being convenient for seizings, service, &c., where great neatness is not required.

Houseline, Roundline and **Marline** are used for the same purposes as spun-yarn, but make neater work, being laid up more smoothly and of a better material.

Marline is 2-stranded left-handed, houseline 3-stranded left-handed, and roundline 3-stranded right-handed. All of the above are used for seizings, but where a heavier and stronger material is needed, a higher grade of stuff is used, laid up by rope-making machinery and finished like the larger sizes of rope, although classed as small stuff. This is called *Seizing Stuff*. It is usually 3-stranded, right-handed, and may have 2, 3 or 4 threads to the strand, making 6-thread, 9-thread or 12-thread seizing stuff.

Ratline Stuff does not differ from seizing stuff in its general characteristics, but is larger. It is 3-stranded right-handed, and may have 4, 5, 6, 7 or 8 threads to the strand, making "12-thread," "15-thread," "18-thread" Ratline Stuff, and so on.

Rope-yarns are used for many purposes on board ship, and a good supply of them should always be on hand. They are made from condemned hemp cordage, tarred.

Two yarns twisted up together by hand, or single yarns twisted up against their natural lay and rubbed smooth, are called "foxes" and are often used for light seizings, being much neater than spun yarn.

Rope tends to contract when wet, and unless allowed to do so freely may be injuriously strained. It is for this reason and to prevent danger to the yards, etc., that running gear is slacked in damp weather. On the other hand, advantage may be taken of this tendency for tautening lashings, etc., by wetting the rope.

As rope deteriorates rapidly from continued dampness it should never be stowed away unless perfectly dry. This caution is especially important in the case of hawsers, which are rarely used without being wet. It is a reason also for the rule that hemp and manila block-straps should not be covered except when absolutely necessary, as the covering not only holds the moisture but prevents the deterioration from being seen.

Unlike the metals and other similar substances, rope made of vegetable fibre has not a permanent elastic limit within which it may be worked indefinitely without injury. Owing to the tendency of the fibres to slip one upon another, the rope gradually loses its cohesion under the repetition of very moderate tensions, and may be seriously weakened by constant working, without ever having been subjected to anything approaching a breaking stress; while if subjected even once to a stress approaching that of breaking, its strength is permanently reduced and it may be expected to give way under a very moderate pull.

Wire-rope is made of steel or iron wires laid up like yarns to form strands, which strands are in turn laid up to form a rope. The characteristics of the wire and the manner of making it up vary within wide limits in accordance with the purpose for which the rope is intended. Where great flexibility is wanted, as in the case of rope to be worked over pulleys, this quality is secured at some sacrifice of strength. Such rope should not be galvanized unless it is to be exposed to the weather or to extreme dampness. Where a steady stress is to be provided for, as in the case of standing rigging, the tensile strength is of maximum importance; and in this particular instance (standing rigging) galvanizing is essential because of the necessary exposure to weather. The number of strands will depend upon the purpose for which the rope is designed, as will also the nature of the heart. As a rule, six strands are used, laid up around a hempen heart. The number of wires to a strand may be anywhere from 3 to 50 or even more. Flexibility is secured by the use of a large number of small wires laid up around hemp hearts to form strands which are in turn laid up, also around a hemp heart, to form the rope, and by the use of a comparatively sharp twist. Where flexibility is not important, the strands sometimes have wire hearts. This may add as much as 10 per cent to the strength, but would not do for any but stationary ropes, as the wear from the friction of a wire core upon the wire strands would be a serious matter for running gear, hawsers, &c.

Plate **10** shows types of wire-rope as made for various purposes.

Plate No. 11.

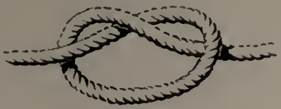


Fig. 1.
Overhand Knot.

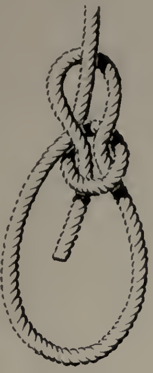


Fig. 2.
Bowline.

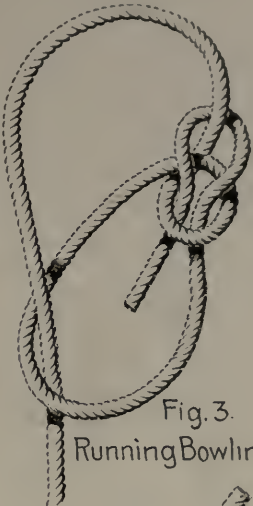
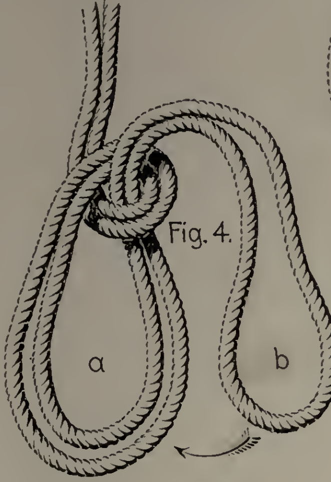


Fig. 3.
Running Bowline

Fig. 4.



Bowline on a Bight (1.)

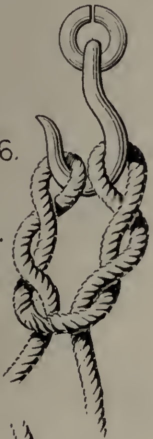


Fig. 6.
Cat's paw.

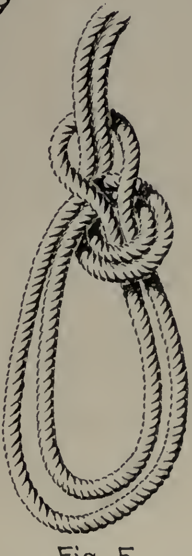


Fig. 5.
Bowline on a Bight (2.)

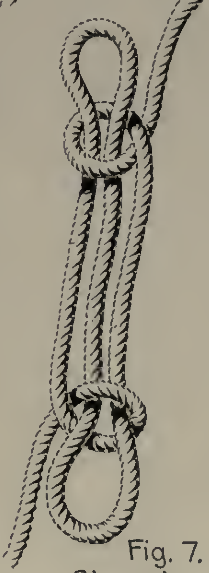


Fig. 7.
Sheepshank.

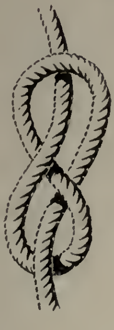


Fig. 8.
Figure-of-Eight Knot.

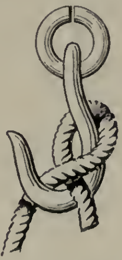


Fig. 9.
Single Blackwall Hitch.

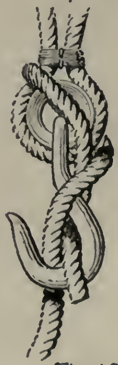


Fig. 10.
Double Blackwall Hitch.

KNOTS IN THE END OF A ROPE.

The hemp heart is thoroughly saturated with tar to prevent it from absorbing and holding moisture, which might attack the wire from the inside.

Galvanizing is the simplest and most efficient means known of preserving wire from rusting, but it involves exposing the wire to a very high temperature, which for certain grades of steel may be injurious. A process of zinc electro-plating has been tried with considerable success, but has not come into general use, because of its expense.

Wire is used for most of the standing rigging of modern ships, and for pendants, spans, ridge-ropes, and other fittings. It is rarely used on ship-board for running gear except in a single pendant.

Wire hawsers are much used in towing, for which work they have many advantages and some serious disadvantages. (See Chapter on Towing.)

Wire-rope requires in some ways better care than hemp or manila and far better care than it generally receives on shipboard. It should be kept on a reel when not in use, and great care should be taken at all times to avoid kinks and sharp nips. A single kink in the finest wire-rope practically ruins it at once. A wire hawser should be gone over thoroughly every month or two with raw linseed oil; or, better, if it is not to be used for some time, with a paint made of equal parts of linseed oil and lamp-black. Neither oils nor tars can be regarded as perfect preservatives, as they all contain more or less acid, which attacks the steel. The principal reliance must therefore be upon the galvanizing. If the rope is to remain under water for some time, the best preservative is made by adding to one barrel of Stockholm tar, one barrel of fresh slacked lime. Boil well and use while hot for saturating the rope.

Wherever wire-rope is to be worked over a sheave, the diameter of the sheave and the speed of running become very important factors. The larger the sheave and the lower the speed, the better. All manufacturers of wire-rope prescribe a minimum diameter for sheaves, and their guaranteed breaking strains and estimated safe-working loads are for these minimum diameters, and for moderate speed. A high speed increases the wear upon the rope, not only by the friction on the pulley, but still more by the friction of the wires upon each other—a point which is often overlooked. A small sheave also increases the wear and at the same time weakens the rope directly by the distortion of the fibres. This will be discussed more fully in the Chapter on Tackles.

The wire-rope used in the United States Navy is manufactured at the Boston Navy Yard and made from galvanized steel wire either "hard" or "annealed." The hard wire has a tensile strength of from 175,000 to 200,000 lbs. to the square inch, the annealed wire of 80,000 lbs. The use of annealed wire is limited to certain special situations where great strength is not important. All varieties are six-stranded, plain-laid, the number of wires to a strand depending upon the purpose for which the rope is to be used.

THE STRENGTH OF ROPE.

The following table gives the ultimate strength of ropes of different sizes as determined from actual experiment upon new rope of good quality. For a working load, with wire not more than one-sixth of the ultimate strength should be used if working around a pulley. A considerably greater load may be used where the rope is worked straight.

STRENGTH OF ROPE.
Manila and Wire.

Circumference	MANILA		FLEXIBLE STEEL-WIRE ROPE (Galvanized)						REMARKS
			For Running Gear (Fig. 2, Plate 10)		For Towing Lines (Fig. 2, Plate 10)		For Towing Lines [1] (Fig. 5, Plate 10)		
	Breaking Strain	Working Load	Breaking Strain	Working Load	Breaking Strain	Working Load	Breaking Strain	Working Load	
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
1.			4500	710					If wire-rope is worked around small sheaves, belayed to posts, or used with a sharp nip, its strength is enormously reduced.
1½	2300	1000	7000	1150					
2.	3000	1400	9000	1500					
2½	4500	2000	11000	1800	30000	5000	44000	7000	
3	6500	3000	14000	2300	44000	7000	64000	10000	
3½	9000	4000			54000	9000	88000	15000	
4	12000	5500			68000	11000	114000	18000	
4½	15000	7000			86000	14500	142000	23000	
5.	18500	8500			105000	17000	170000	28000	
5½	23000	10500			128000	20000	204000	32000	
6.	26500	12500			160000	26000	230000	38000	
7.	36000	15000							A well-made splice weakens wire by from 10 to 15 per cent.
8.	47000	22000							
9.	60000	28000							
10.	75000	35000							

[1] Observe that this is a special type and of very exceptional strength.

Plate No. 12.

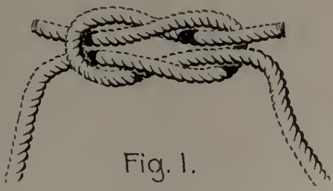


Fig. 1.

Square or Reef Knot.

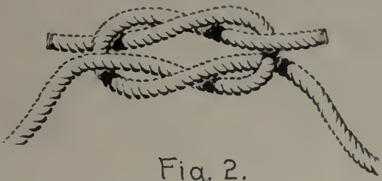


Fig. 2.

Granny Knot.

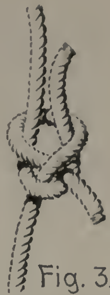


Fig. 3.

Sheet or Becket
Bend Single.

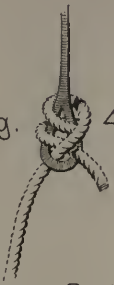


Fig. 4.

Sheet or Becket
Bend Double.

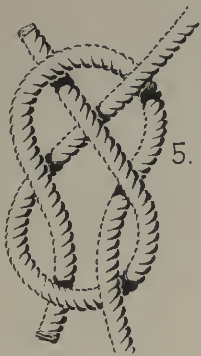


Fig. 5.

Single Carrick Bend (1.).

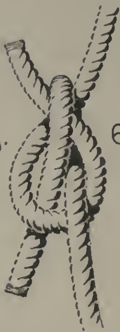


Fig. 6.

Single Carrick Bend (2.)

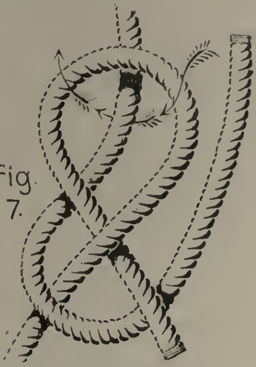


Fig. 7.

Double Carrick Bend (1.)

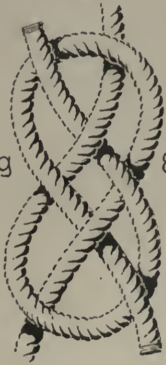


Fig 8.

Double Carrick Bend (2.)

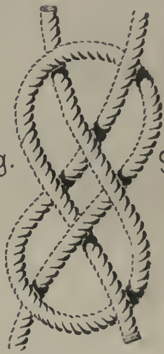


Fig. 9

Double Carrick Bend.
(2nd Method)

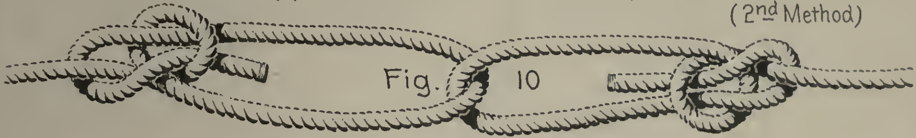


Fig. 10

Two Bowlines

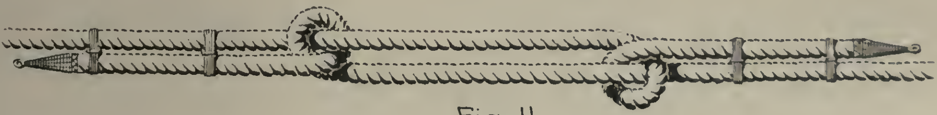


Fig. 11
Reeving-Line Bend.

BENDING TWO ROPES TOGETHER.

Plate No. 13.

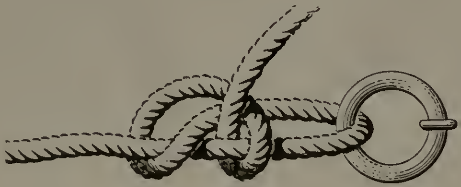


Fig. 1.
Studding Sail Tack Bend.

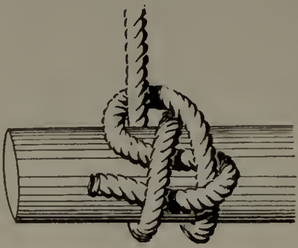


Fig. 2.
Studding-Sail
Halliard Bend.

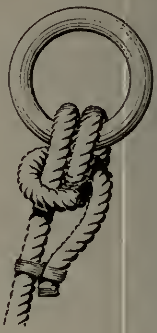


Fig. 3.
Fisherman's Bend.

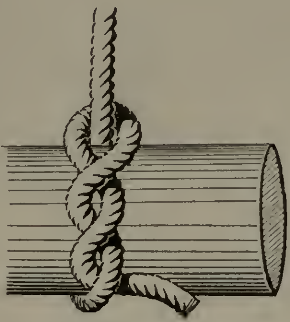


Fig. 4.
Timber Hitch.

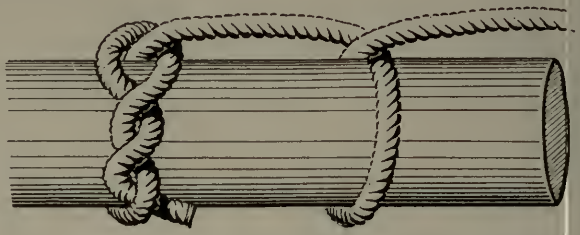


Fig. 5.
Timber and Half Hitch.

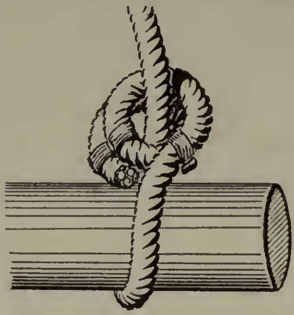


Fig. 6.
Inside Clinch.

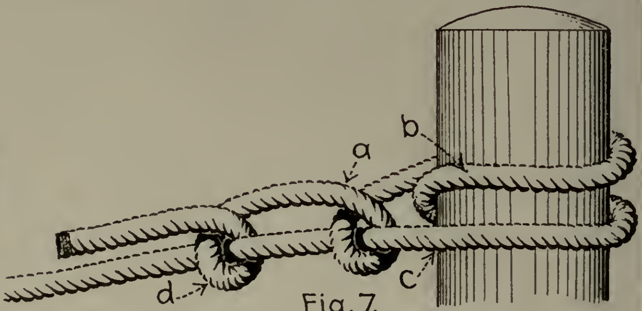


Fig. 7.
Round Turn and Two Half Hitches.

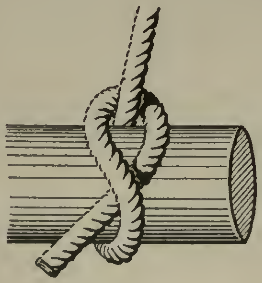


Fig. 8.
Half Hitch.

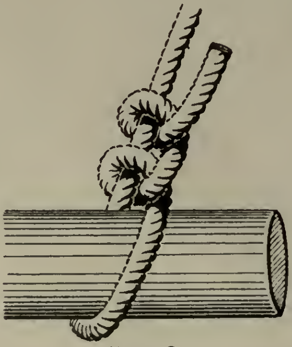


Fig. 9.
Two Half Hitches.

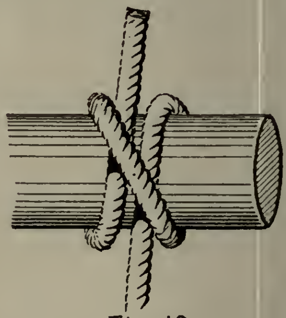


Fig. 10.
Clove Hitch.

BENDING A ROPE TO A POST OR SPAR.

Rules for calculating the approximate strength of hemp and manila ropes from the circumference are given at the end of the Chapter on "Tackles." It is impossible to give similar rules for wire-rope, as the strength varies enormously with the method of manufacture.

§ II. KNOTTING AND SPLICING.

The art of working in rope cannot be learned from a book, but the illustrations which accompany this Chapter will give an idea of the most common knots, splices, etc., in general use and should be helpful up to a certain point in making them.

PLATE **11** shows a number of simple knots, all of which are made with a single rope.

An Overhand Knot. Fig. 1.

A Bowline. Fig. 2. One of the most common and useful knots known to Seamanship. It forms a loop, which may be of any length, and which cannot slip; as the heavier the pull upon it, the tighter it jams. Moreover, it does not form so sharp a nip as to weaken the rope. It is used for lowering men over a ship's side, for slinging them from stays, etc., while working aloft, and for a great variety of similar purposes. A common use of it is to form a loop in the end of a hawser to be thrown over a bollard, in working a ship alongside a dock.

A Running Bowline. Fig. 3. A convenient form of running loop. The loop of the bowline proper is usually smaller than that shown in the figure.

A Bowline on a Bight. Figs. 4 and 5. Used in place of a single bowline where greater strength is needed, or an increased number of parts.

A Cats-paw and **a Blackwall Hitch.** Figs. 6, 9 and 10. Used for hooking a tackle to the end of a rope. The double Blackwall is sometimes called a **Stunner Hitch.**

A Sheep-shank. Fig. 7. A quick and convenient way of temporarily shortening a rope.

A Figure-of-Eight-Knot. Fig. 8. Turned in a rope to prevent it from unreeving. It will not jam as an overhand knot would do.

PLATE **12** shows the most common knots used for connecting two ropes or two ends of the same rope.

A Square-knot or **Reef-knot.** Fig. 1. This is the simplest knot of the series and the most useful. It should be carefully distinguished from the "Granny-knot" (Fig. 2), which does not hold as well and is hard to untie. A square-knot will not answer for uniting ropes of different sizes, as the parts would slip unless stopped down.

A Sheet or Becket Bend. Fig. 3. Called by landsmen a "Weaver's Knot." May be used where the parts are of different sizes.

A Sheet Bend, double. Fig. 4.

A Single Carrick Bend. Figs. 5 and 6.

A Double Carrick Bend. Figs. 7, 8 and 9. Commonly used for bending hawsers together. If the two parts are of different sizes it is well to seize each part back on itself.

Two Bowlines, Fig. 10, and a **Reeving-line Bend,** Fig. 11, are also used for bending hawsers together. The reeving-line bend is particularly useful where the lines are to be veered out through a small pipe.

PLATE **13.** The figures of this plate show a number of methods of securing lines to spars, posts, rings, etc.

A Studding-Sail Tack Bend. Fig. 1. Will not come adrift by the flapping of the sail.

A Studding-Sail Halliard Bend. Fig. 2. Lies flat to the yard.

A Fisherman's Bend. Fig. 3.

A Timber Hitch. Fig. 4.

A Timber and Half Hitch. Fig. 5. For towing or dragging a spar.

An Inside Clinch. Fig. 6.

A Round Turn and Two Half Hitches. Fig. 7. For making a hawser fast to a bollard. For greater security, the end should be stopped down to the main part. If the part *a* is taken up under *b* as well as under *c*, we have a Fisherman's bend, which, with a half hitch outside it as at *d*, is often used for this purpose. A more convenient way is to turn a bowline in the end of the hawser and throw it over the post.

PLATE **14** shows a series of knots which are worked in the end or the body of the rope by unlaying the rope and using its own strands. A whipping is usually put on below the point where the knot is to be. Knots of this kind are sometimes used to give a finish to the end of the rope, sometimes to prevent it from unreeving, and sometimes merely for ornamental purposes.

Plate No. 14.

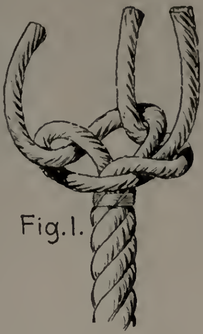


Fig. 1.

Wall Knot.

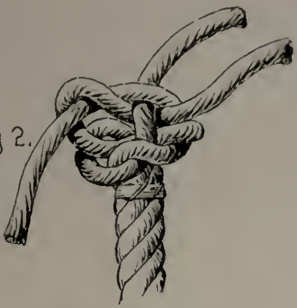


Fig 2.

Wall and Crown.

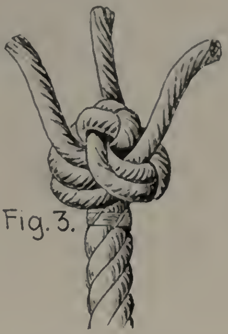


Fig. 3.

Double Wall and Single Crown.

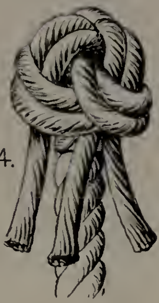


Fig. 4.

Double Wall and Double Crown
or "Man Rope Knot."

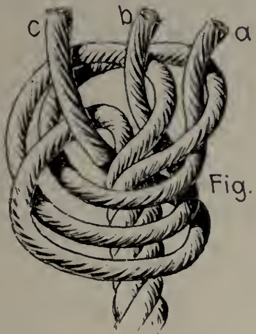


Fig. 5.

Double Matthew Walker (1.)

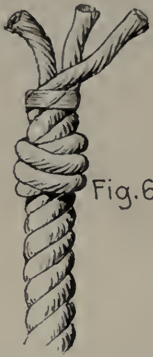


Fig. 6.

Double Matthew Walker (2.)

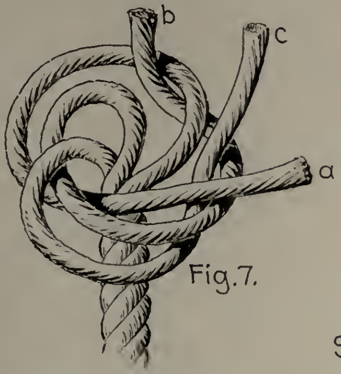


Fig. 7.

Single Matthew Walker (1.)

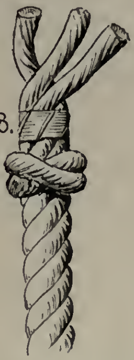


Fig. 8.

Single Matthew Walker (2.)

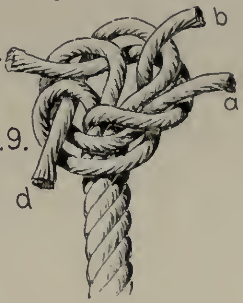


Fig. 9.

Laniard Knot (1.)

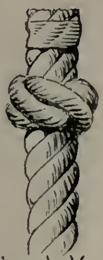


Fig. 10.

Laniard Knot (2.)

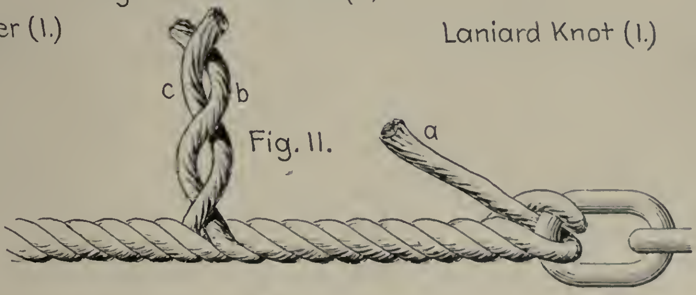


Fig. 11.

Chain Splice.

KNOTS WORKED IN THE END OF A ROPE.

Plate No. 15.

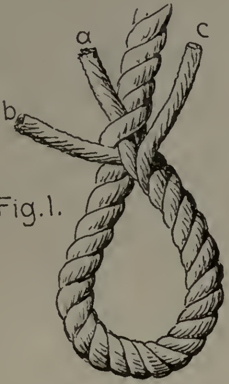


Fig.1.

Eye Splice.(1)

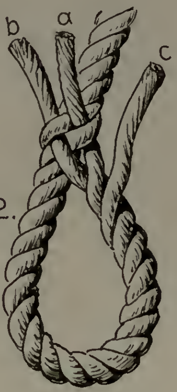


Fig.2.

Eye Splice.(2)

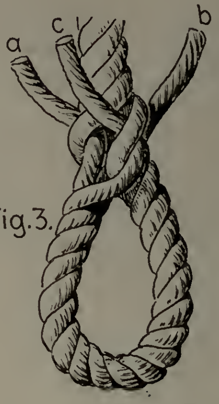


Fig.3.

Eye Splice. (3)

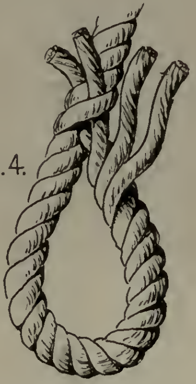


Fig.4.

Eye Splice, 4-Stranded Rope.

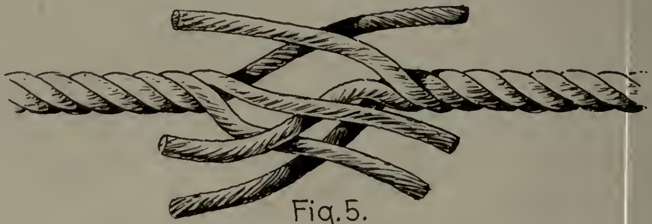


Fig.5.

Short Splice.(1)

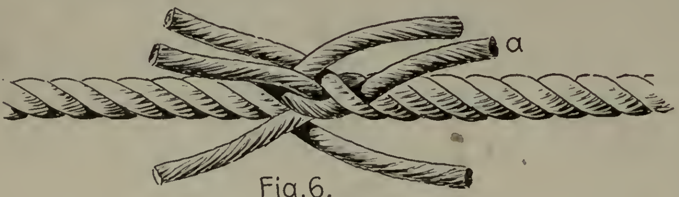


Fig.6.

Short Splice.(2)

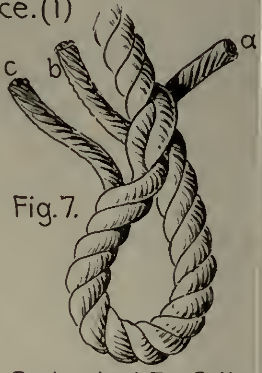


Fig.7.

Sailmaker's Eye Splice.(1)

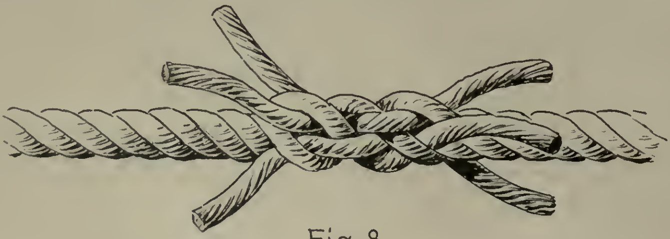


Fig.8.

Short Splice.(3)

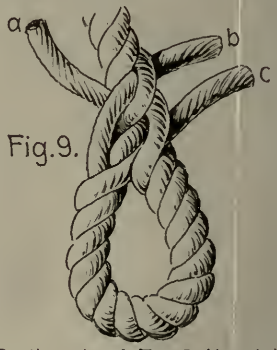


Fig.9.

Sailmaker's Eye Splice.(2)

Splices.

A Wall-knot. Fig. 1.

A Wall and Crown. Fig. 2.

A Double Wall and Single Crown. Fig. 3.

A Double Wall and Double Crown or "**Man-rope Knot.**" Fig. 4. Used on the ends of "man-ropes" (trailing-lines over the sides) to give a good hold for a man overboard.

A Matthew-Walker Knot, double and single. Figs. 5 and 6, 7 and 8.

A Lanyard Knot. Figs. 9 and 10. Used on the end of a lanyard to prevent unreeving through the dead-eye.

A Chain Splice. Fig. 11. For splicing a rope to a chain.

PLATE **15** shows various forms of **splices** for joining the ends of two ropes permanently, or for bending back the end of a rope upon itself to form a permanent eye. In cases like this and those which follow, where the strands of a rope are to be *tucked*, the lay of the rope where they go through is opened out by means of a marline-spike, and the strand tucked through once in its full size, then reduced in size by cutting away a certain number of threads, tucked a second time, reduced once more in size and tucked again. It is thus tucked once full size, once two-thirds, and once one-third. This produces a tapered and much neater splice than if it were tucked three times in full size.

An Eye-splice in three-stranded rope. Figs. 1, 2 and 3. The rope is unlaid for perhaps a foot from the end, and the strands brought back upon the body of the rope at a point which will form an eye of the size that is wanted. Beginning with any one strand, this is tucked from left to right, through the strands of the rope (which are opened out by a spike), being passed over one and under the next. The other two strands are similarly tucked, always from right to left. All three are then trimmed down to two-thirds their original size, tucked again, trimmed to one-third size and tucked a third and last time.

An Eye-splice in four-stranded rope. Fig. 4. Here the first strand is tucked under two; but this for the first tucking only.

A Sailmaker's Eye-splice. Figs. 7 and 9. Used on the roping of sails because it continues the original lay of the rope around the eye and is thus more convenient for sewing to canvas.

A Short Splice. Figs. 5, 6, and 8. Two ropes are unlaid for a short distance and married together with strands interlacing

(Fig. 5). The strands of each rope are then tucked through the lay of the other rope exactly as has been described in the case of an eye-splice.

Plate **16.** **A Long Splice.** Figs. 1 and 2. Here the ropes are unlaid for a greater distance than for a short splice and the ends brought together as before, with strands interlacing. Instead now of tucking at once, we proceed as follows: Unlay a_1 one of the strands of A, for a considerable distance, and in place of it lay up b_1 the adjoining strand of B, thus working a strand of B into A, for, say, a foot and a half or two feet. For convenience now twist up a_1 and b_1 together temporarily, as in Fig. 2. Turn the rope end for end, unlay b_2 one of the strands of B, and in place of it lay up a_2 the adjoining strand of A. a_3 and b_3 are left lying beside each other without being unlaid. We now have three pairs of strands at different points of the rope. Beginning with a_2 and b_2 (for example) separate each of these strands into two parts, and taking one-half of each strand, overhand knot these together (K. Fig. 2) and tuck them as in a short splice, over one and under one of the full remaining strands of the rope. (M. Fig. 2.)

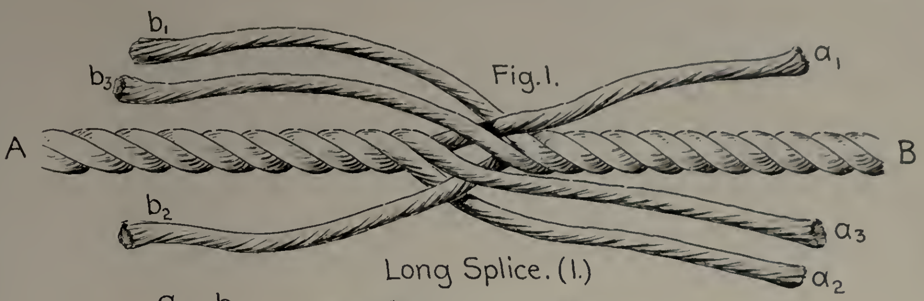
The other pairs of strands (a_1 b_1) (a_2 b_2) are similarly reduced, knotted, and tucked. The spare half of each strand is trimmed off smooth, as are the ends of the other halves after they have been tucked.

Working in Wire Rope.

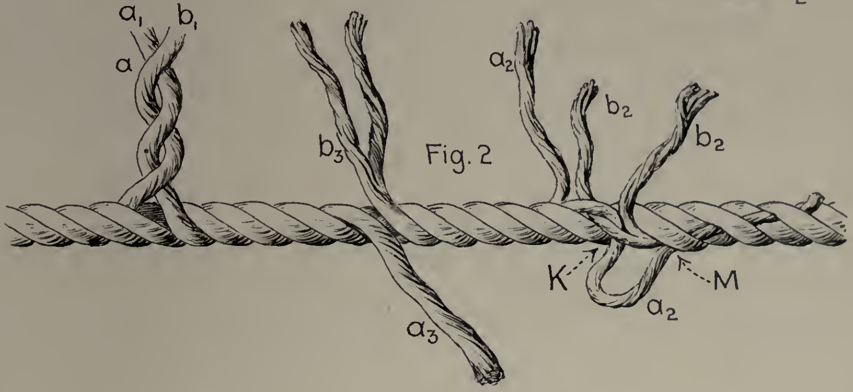
As already stated, wire-rope is usually six-stranded, with a hemp heart. In splicing, we may work with the strands separately or in pairs. The work calls for special appliances and for a degree of skill such as can be acquired only by long practice under expert instruction. Something may be learned from careful description, and much more from an occasional visit to a rigging loft; but the facilities which are available on shipboard, do not admit of doing such work as is possible with a rigger's bench, a turning-in machine, etc. Where a heavy rope is to be bent around a thimble or the parts otherwise brought together for splicing or seizing, a rigger's-screw is needed. (Plate **25**.) In the absence of this, a vise may be used, but less conveniently.

In tucking the strands of a splice, the lay of the rope is opened out and *the spike left in*, holding the strands apart, until the tuck

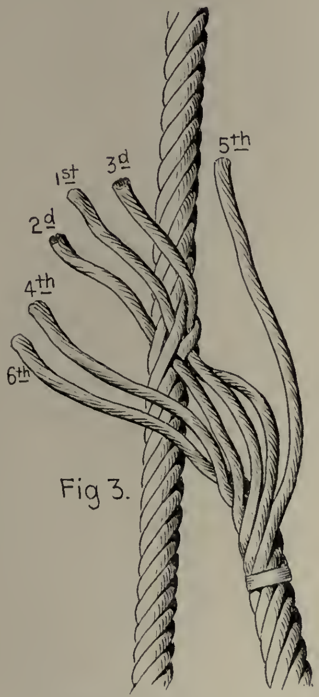
Plate No. 16.



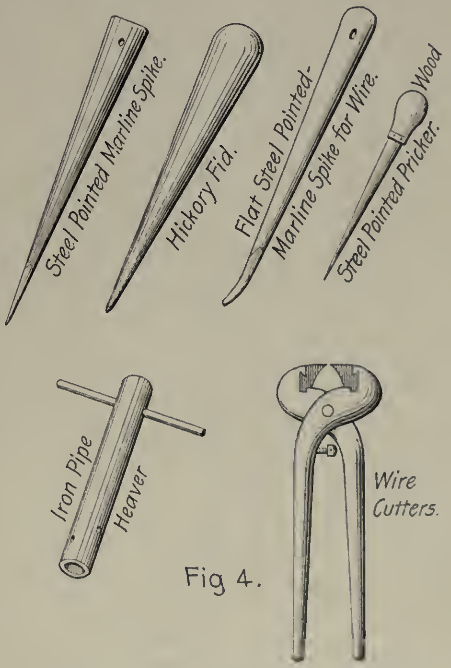
Long Splice. (1.)



Long Splice. (2.)



Eye Splice in Wire.



Tools Used in Splicing
Rope.

SPLICING.

Plate No. 17.

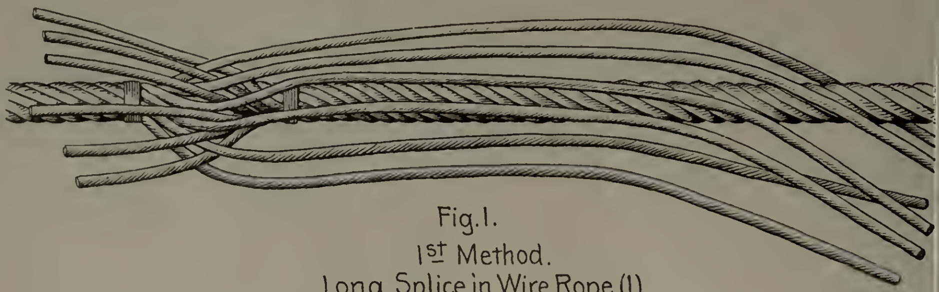


Fig. 1.
1st Method.
Long Splice in Wire Rope. (1)

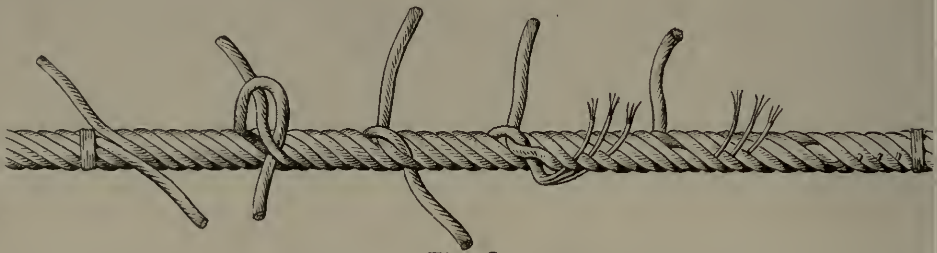


Fig. 2.
1st Method.
Long Splice in Wire Rope. (2)

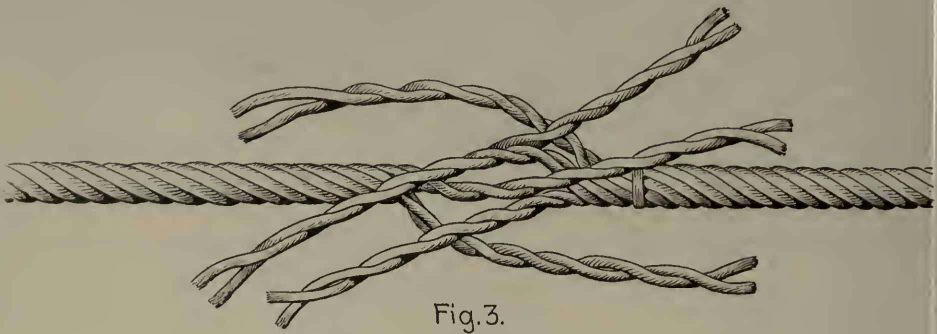


Fig. 3.
2d Method.
Long Splice in Wire.

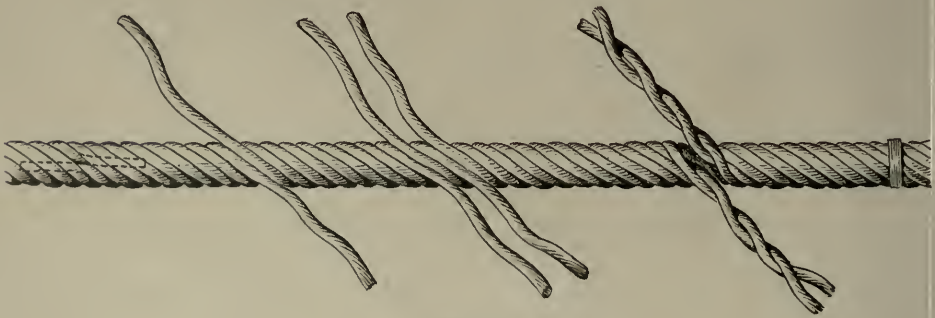


Fig. 4.
2d Method.
Long Splice in Wire.

LONG SPLICE IN WIRE.

has been made. For dragging the strands through, a jigger is used on each one, the body of the rope being held by another jigger or a lashing. After a tuck, the parts of the ropes are hammered down tightly upon each other. Wire-cutters are used for cutting off ends.

Fig. 4, Plate **16**, shows the tools used in working in wire on shipboard.

Plate **16**. **An Eye-splice in Wire.** Fig. 3. Get the rope on a stretch, allow from 18 to 24 inches from the end for splicing, and put on a mark with a couple of turns of twine. Measure along the rope from this mark the length of the eye (once and one-half the round of the thimble) and put on another similar mark. Paint with red lead, worm, parcel, paint again, and double-serve between the marks. Now come up the stretch and seize the thimble in, breaking the rope around by the rigger's-screw and putting on a good racking seizing around both parts. Come up the screw, unlay the end of the wire, and cut out the heart close to the service. Now, with the thimble toward you, counting from right to left 1, 2, 3, etc., stick No. 4 strand from right to left under the upper strands of the rope just clear of the service, opening the strands by a spike. Haul through by hand. In the same manner—under two and over one strand—tuck the remaining strands, in the following order: 3, 5, 2, 6, 1. Now, commencing with any strand, tuck again whole and haul through by means of a jigger. Hammer the strands down in place, cut each strand down to one-half size and tuck again, hauling through with a jigger as before. Cut the strands down to one-quarter and tuck again. Hammer down all strands and cut off the wire with a wire-cutter.

Plate **17**. **A Long Splice in Wire.** Figs. 1 and 2. Put on a good seizing six to ten feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one to two feet from the end of the other rope. Unlay, open out the strands, cut out the heart, and marry the ends together with strands interlacing. Cut the seizing on the short end. Unlay one of the short strands, following it up in the same lay with the opposite long strand, leaving end enough to tuck. Continue in the same manner with the remaining strands, except as to the distance to which they are laid up, this distance being varied in such a way as to leave the successive pairs an equal distance apart, as shown in Fig. 2. Commencing with any two strands, half knot them together (full size), then divide each into three parts, and tuck these parts separately as shown;—or, cut out a few inches of the heart and insert the ends of the strands in its place in the center of the rope. When a splice is to be served, the latter way of finishing it off answers very well, but not otherwise.

Note that this splice is made by working always to the right, the strands of A (long strands) being all worked into B.

A Long Splice in Wire. Figs. 3 and 4 (second method). Put on a good seizing an equal distance from the ends of the ropes to be spliced, from six to ten feet, according to the size of the rope. Unlay the strands in pairs, cut out the heart, marry together (Fig. 3), and lay up the strands in the same manner as in an ordinary three-stranded long splice in hemp, so that the strands meet an equal distance apart (Fig. 4). Then take any two ends (double strands), separate the strands, unlay one of these single strands, of A for example, and follow up in the lay with one of the corresponding single strands of B. The other single strand of A in the original pair, is left, with the corresponding single strand of B lying alongside of it. This is repeated with each of the original double strands. There are now six sets of single strands of A and B lying together at different points of the rope, ready for tucking. The splice is finished off either by overhand knotting these ends, or by inserting the ends in place of the heart.

In view of the difficulty and delay involved in splicing wire rope, it is often convenient to make use of other methods for making an eye or of joining two ropes temporarily. For this purpose, use may be made of the clamps shown in Plate 10. These are quickly and easily applied, and where several of them are used together, they may give nearly or quite as strong a connection as a splice.

PLATE **18.** **A Short Splice in Wire.** Fig. 1. Put on a good seizing two or three feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one or two feet from the end of the other rope. Unlay the ends and open out the strands, cutting out the heart close to the seizings. Marry them together and clap on a temporary seizing around the short ends and the body of the rope, to hold the parts close together. Commencing with any one of the long strands, tuck each in succession over one and

Plate No. 18.

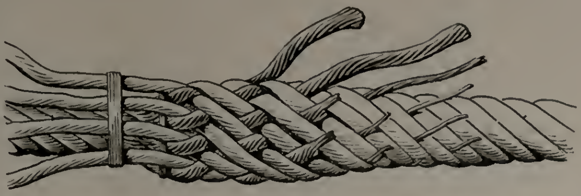


Fig. 1.
Short Splice in Wire.

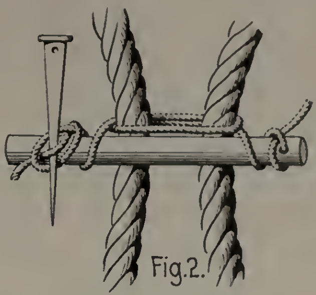


Fig. 2.
Spanish Windlass.

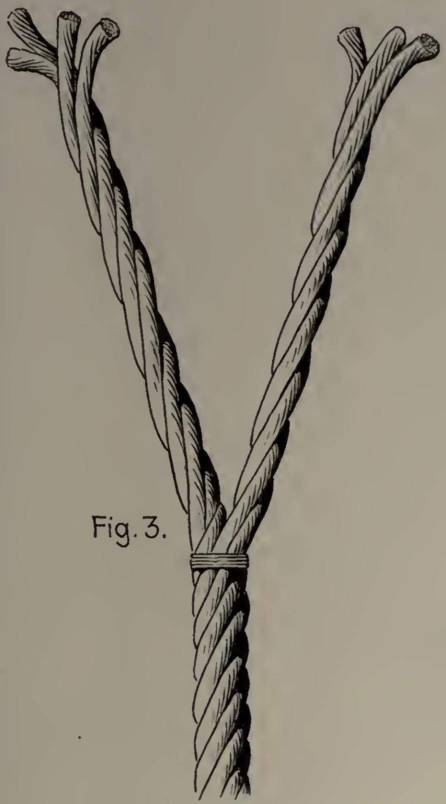


Fig. 3.
Collar for a Wire Stay (1.)

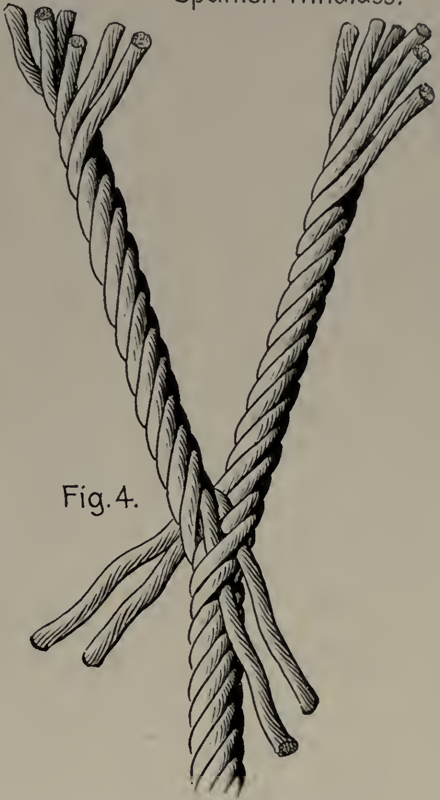


Fig. 4.
Collar for a Wire Stay (2.)

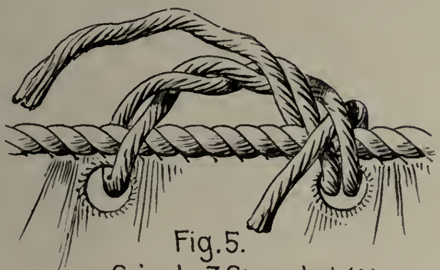


Fig. 5.
Cringle 3 Stranded (1.)

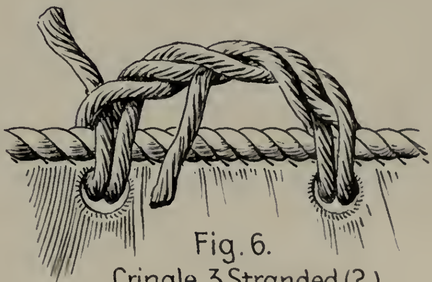
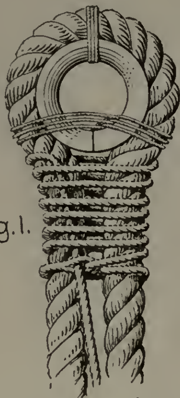


Fig. 6.
Cringle 3 Stranded (2.)

SPLICING. CRINGLE.

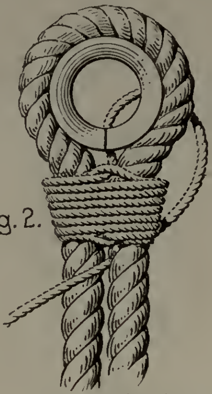
Plate No. 19.

Fig. 1.



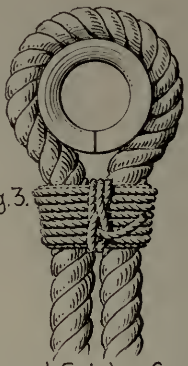
Round Seizing.
1st Method. (1)

Fig. 2.



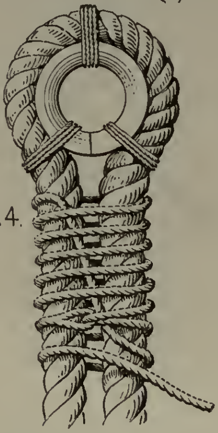
Round Seizing.
1st Method. (2)

Fig. 3.



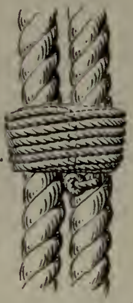
Round Seizing Crossed.
Clove Hitch Finish. (3)

Fig. 4.



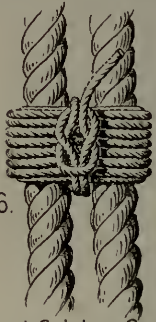
Round Seizing.
2d Method.

Fig. 5.



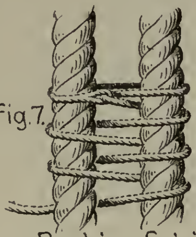
Round Seizing without Cross.
Overhand Knot
Finish

Fig. 6.



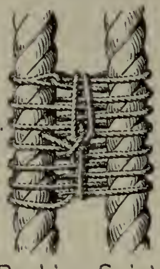
Round Seizing Crossed.
Square Knot
Finish.

Fig. 7.



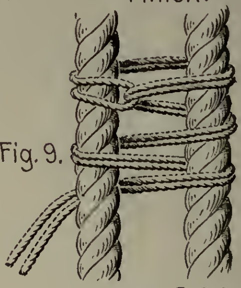
Racking Seizing.
1st Method. (1)

Fig. 8.



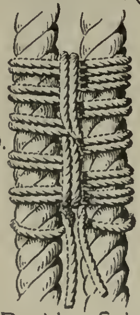
Racking Seizing.
1st Method. (2)

Fig. 9.



Racking Seizing.
2d Method

Fig. 10.



Racking Seizing.
2d Method. (2)

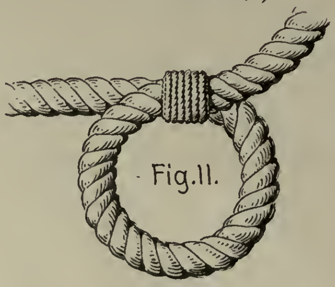
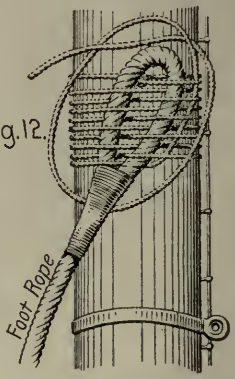


Fig. 11.

Throat Seizing.

Fig. 12.



Rose Lashing.

SEIZINGS.

under two strands, opening out the lay with a spike. Tuck the remaining strands in the same manner;—twice whole strands, once one-half, and once one-quarter, hauling through with a jigger each time. Then turn the splice around, cutting the temporary seizing on the short ends, and tuck the short strands once one-half and once one-quarter, heaving them through with a jigger. Hammer down all parts and trim off the ends.

A Spanish Windlass. Fig. 2.

For heaving two parts of a rope together.

A Collar for a Wire Stay. Figs. 3 and 4. The method of Fig. 3 gives to each leg only half the strength of the stay. That of Fig. 4 is to be preferred.

Working a Cringle on the leech of a sail. Figs. 5 and 6.

PLATE **19** shows different forms of seizings for binding together two ropes or two parts of the same rope. The manner of passing them is made clear by the figures. With heavy ropes, the parts must be hove together by power of some kind, such as a Spanish Windlass, a rigger's-screw, or a turning-in machine.

CHAPTER III.

SPARS AND STANDING RIGGING.[1]

§ I. MASTS.

Lower masts in modern ships are usually built up of steel plates stiffened in various ways by steel shapes. (Plate **20**.)

Built-up masts of wood are no longer used, although lower masts made of single pine sticks are not uncommon in sailing ships of moderate size.

Topmasts and topgallant masts are still made of wood, usually of pine.

The details of masts are shown in Plates **20** and **21**.

The mast rests on a step, placed as low as possible; usually on the keelson. At the lower end is a tenon fitting into a mortise at the step. Where the mast passes through the successive decks, timbers are built in from beam to beam, forming partners; the space between these and the mast being filled by tightly-fitting wedges.

The masthead is smaller than the body of the mast, and at the shoulder, called the hounds, where the reduction in size is made, heavy knees or bibbs, are bolted on, widening the shoulder and forming a secure support for the trestle-trees; stout fore and aft pieces which, in their turn, support the cross-trees, the top, the topmast, and the eyes of the lower rigging. The cross-trees are athwartship pieces crossing the trestle-trees forward and abaft the masthead, and forming the principal part of the framing of the top. They are jogged down into the trestle-trees, and with the latter form a skeleton to which the comparatively light planking of the top is secured.

The lower masthead terminates in a square tenon, to which

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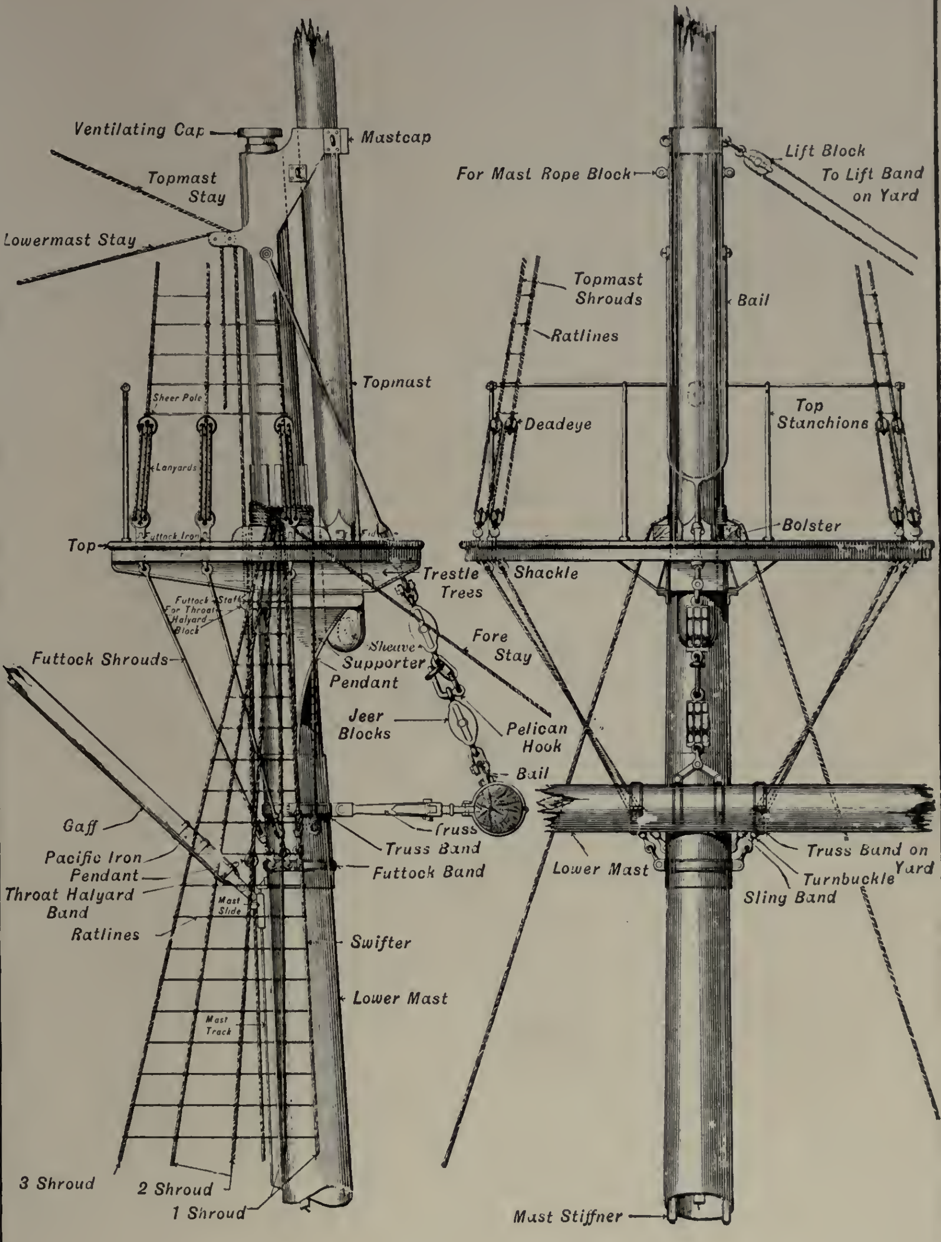
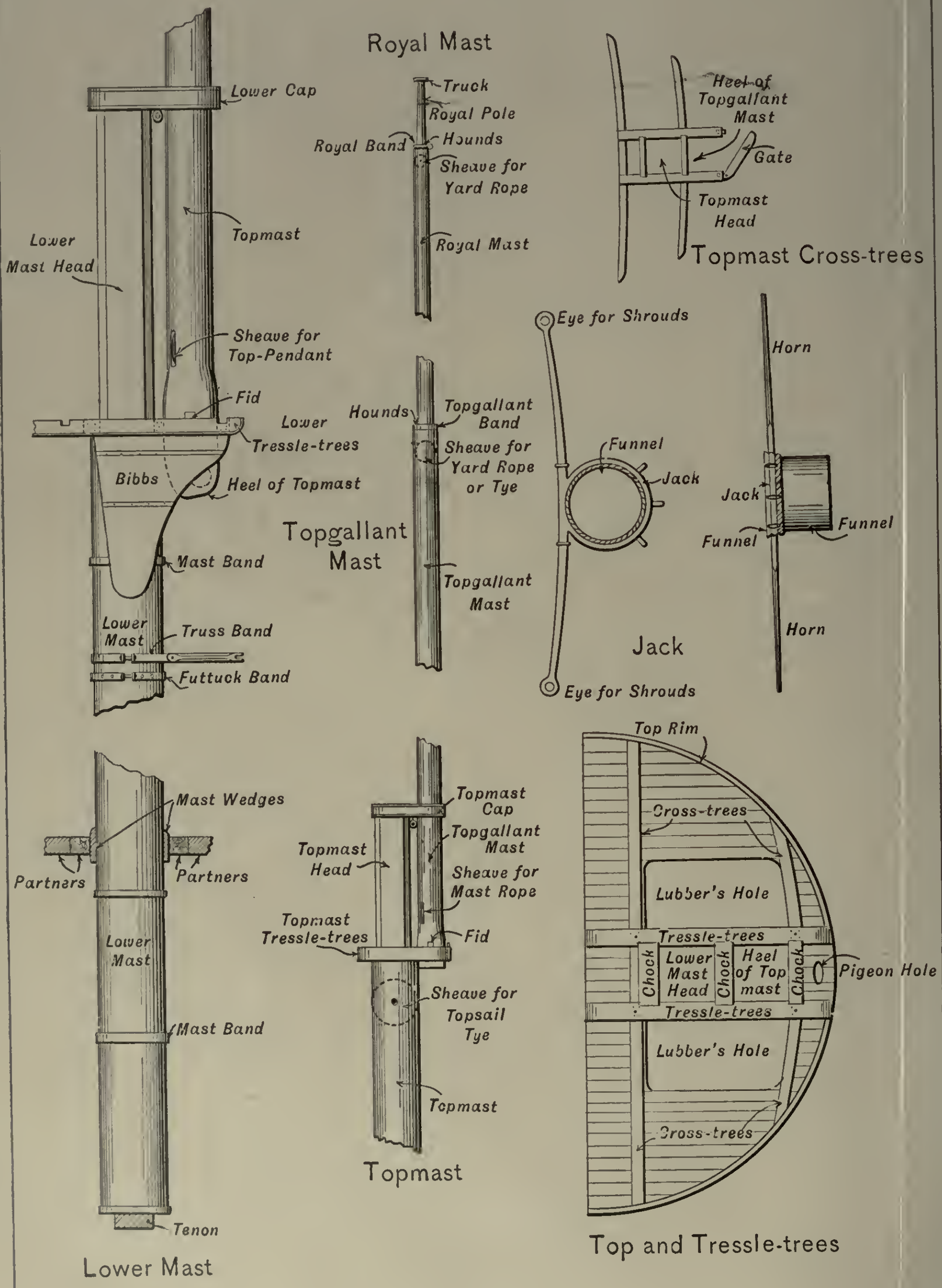
[1] In this and the succeeding chapter (Sails and Running Gear), the text has been made brief because it is considered that the details of Spars, Sails and Rigging can be made clearer by plates than by description. The accompanying plates have accordingly been made unusually full and they should be constantly referred to in reading the text.

Plate No. 20.



FORE TOP OF THE "CHESAPEAKE."

Plate No. 21.



Royal Mast

Topmast Cross-trees

Topgallant Mast

Jack

Lower Mast

Topmast

Top and Tressle-trees

MASTS AND FITTINGS.

the cap is fitted. This may be of wood, iron-bound, or built up of steel as in Plate **20**.

The topmast passes through a round hole in the forward part of the cap, which thus binds the two masts together. In the heel of the mast is a thwartship hole, square in section, through which is placed an iron fid, with its ends projecting and resting on the trestle-trees on either side. Two sheaves placed diagonally in the heel of the topmast furnish a lead for the top pendants, by which the mast is sent up and down. The overlapping parts of the lower masts and topmasts are the doublings.

The topmast head is fitted in practically the same way as the lower masthead, and the heel of the topgallant-mast "doubles" upon it similarly. Cross-trees are used here as spreaders for the topgallant rigging, but without a top. The cross-trees serve an important purpose also in furnishing a foothold for men at the topmast head.

Topgallant and royal masts are in one, but the diameter is reduced at the topgallant masthead forming hounds, upon which rests the topgallant funnel;—a composition cylinder, with two thwartship arms forming the "Jack." At the royal masthead is a similar shoulder, with an iron band for the rigging, and above this is the pole terminating in a tenon to which the truck is fitted. The truck usually carries the point of a lightning conductor, the lower end of which makes contact with the hull, or, in the case of a wooden ship, with the copper well below the water-line.

Trysail masts are fitted up and down abaft the lower masts, being stepped on deck and secured at the head by bands connecting by a key to corresponding bands on the lower mast.

Modern men-of-war rarely carry sail, and such masts as they have are usually for military purposes only;—in some cases for carrying light guns in elevated positions, in other cases merely for signalling. Plate **23** shows the military mast of a battleship.

§ II. YARDS.

A full-rigged ship carries a lower, topsail, topgallant, royal, and sometimes a sky-sail, yard, on each mast. The topsail and topgallant yards are often double.

The details of yards are shown on Plates **20** and **22**.

The midship part of a yard is the slings; outside of this come the quarters, and beyond these the yard-arms. The lower yards are hung by slings, usually of chain, and are held to the mast by trusses, upon which they pivot both horizontally and vertically.

Where the lower topsail yards are double, the lower one is trussed to the lower cap and supported from beneath by a shore. The upper one is held to the mast by a parrel which travels up and down as the yard is hoisted and lowered. The parrel may take the form of a lashing passed abaft the mast between two jaws, or it may be a metal cylinder or "tub," to which the yard is keyed. Where a tub is used, the inner edges, top and bottom, should be rounded off to prevent cutting the mast if the tub cants. The yard is hoisted by a tye, reeving through a block which hooks or shackles to the slings of the yard.

Where a single topsail is used, the yard is fitted as described above for an upper topsail yard.

Topgallant and royal yards are held to the mast by jaws and parrel (Plate **22**), and hoisted by tyes and halliards.

On ships which carry studding sails, booms are fitted on the lower and topsail yards, being secured by *boom-irons.* The booms and their fittings are described in Chapter XXV.

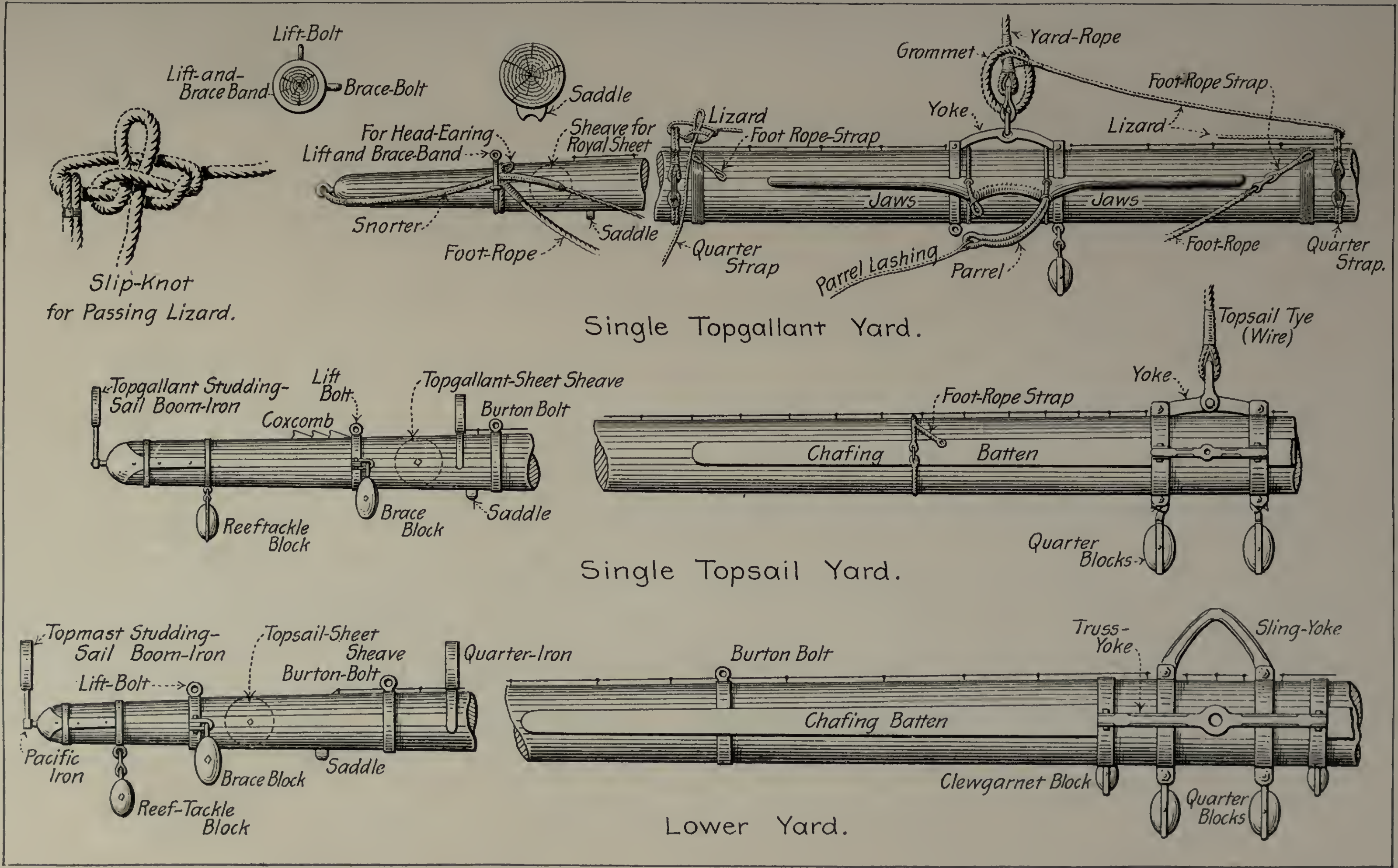
The details of the bowsprit and head booms are shown on Plate **27**; those of gaffs for trysails on Plate **33**.

§ III. STANDING RIGGING.

So great are the variations in the rigging of modern ships, depending in part upon the purposes for which the ships are designed and the amount of sail they are to carry, and in part upon the views of their designers, that it is impossible to give a description of it which shall be anything like universally applicable. The description which follows applies to a sailing man-of-war of recent construction which in its general features is fairly representative of ships which carry sail enough to make their rigging important.

The masts of a ship are supported from the sides by *shrouds,* from forward by *stays* and from aft by *backstays.* The *backstays* contribute also to the sidewise support since they are necessarily led to the sides of the ship. The *stays,* in addition

Plate No. 22.



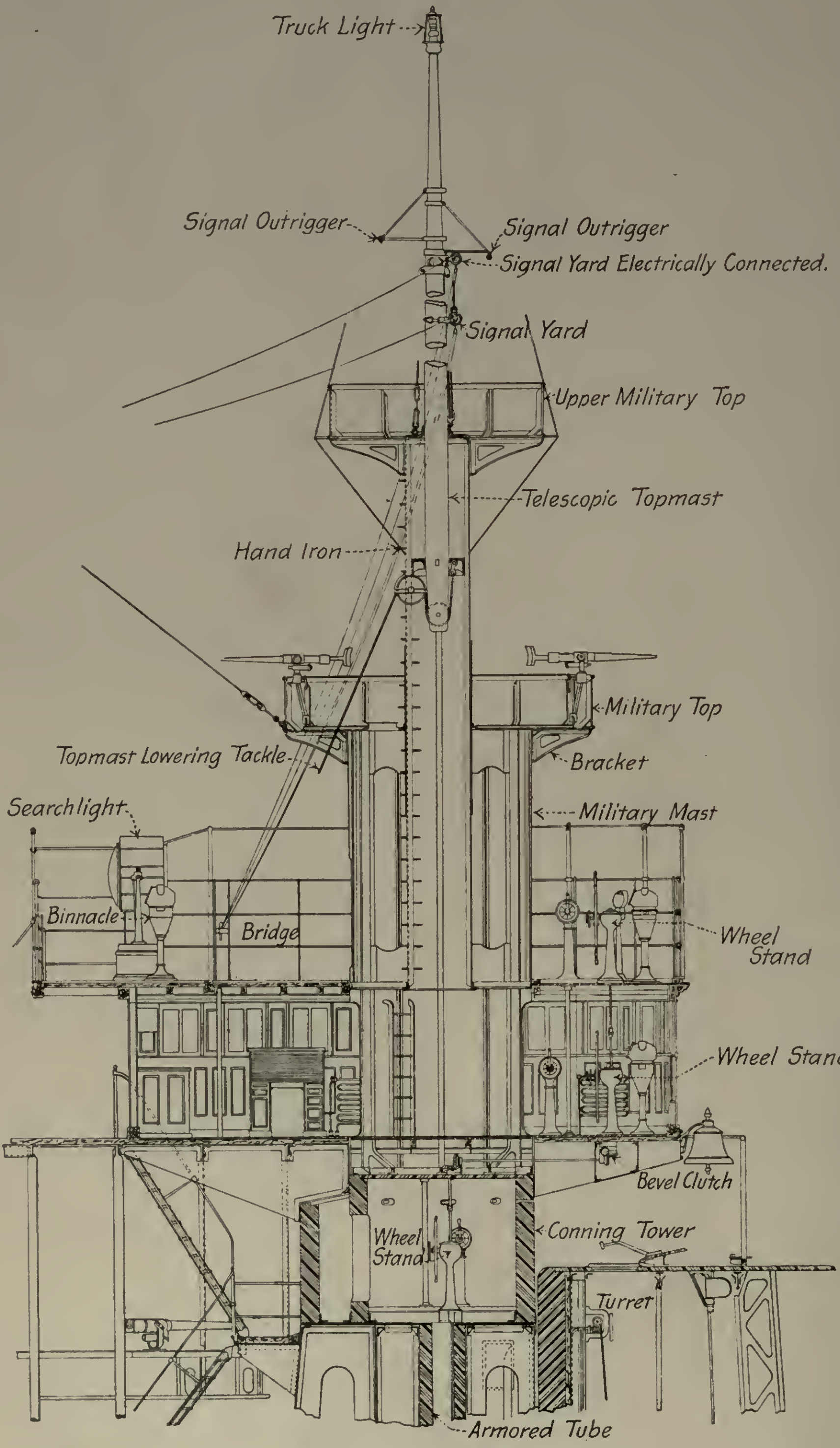
Single Topgallant Yard.

Single Topsail Yard.

Lower Yard.

YARDS AND THEIR FITTINGS.

Plate No. 23.



MILITARY MAST
AND
HAND STEERING GEAR OF A BATTLESHIP.

to supporting the masts, serve to carry certain fore-and-aft sails known as *staysails*. For convenience in hooking tackles at the mastheads for various purposes, heavy *pendants* are provided, fitted with thimbles and links and hanging well clear of the other rigging.

The head-booms are supported from beneath, against the pull of the stays and the lifting tendency of the head sails, by *bobstays*, *martingales*, &c., leading to the cut-water; and from the sides by *bowsprit shrouds, jib-* and *flying jib-guys*, leading to the bow.

The above constitute the "Standing Rigging" of a ship, shown in outline in Plates **28** and **31**, and in detail in Plates **26** and **27**.

Standing Rigging is usually fitted of galvanized steel-wire rope, plain-laid, of six strands, and is protected from the weather, chafe and wear, by a good coating of red lead and oil, then wormed and parcelled with cotton sheeting so laid on and overlapped as to give two thicknesses over all the rope, thoroughly painted again and served. The layers of parcelling are laid on working from down up (with reference to the way the rope will lead when in place), so that they shall shed rain like layers of shingling on a roof. All nips and bends around thimbles and elsewhere are double-served. Fore and aft stays are double-served and covered with leather in the collars and at other points where they are subject to excessive chafe.

Stays which carry sails are left bare in the wake of the hanks and protected by several coats of good asphaltum varnish.

The eyes of shrouds are double-parcelled with tarred canvas and served, after which they are covered with another layer of tarred canvas, called the "heading," which is marled down over all.

The eye-seizings of the shrouds are hove on over a piece of tarred canvas considerably wider than the seizing is to be, so that after the turns are passed the canvas can be turned down over them protecting them from the weather.

The ends of all stays are turned up beneath the standing parts and the ends of shrouds inside the standing parts.

The rigging goes over the various mastheads in the following order:

Lowermast head.—Pendants, Shrouds (in pairs starboard and port alternately), Stays.

Topmast head.—Shrouds (in pairs), Backstays, Stays.

Topgallantmast head.—Stays, Shrouds, Backstays.

Royalmast head.—All standing rigging makes fast to the royal band.

To increase the *spread* of the lower rigging, broad pieces of heavy planking called "chains" or "channels" are, in old-fashioned ships, firmly secured to the side of the ship, with stout iron straps called "chain-plates" leading from their outer edge downward to the side of the ship. To the upper ends of these straps are shackled the lower dead-eyes of the rigging. In modern ships, the channels are dispensed with and the chain-plates are bolted up and down the side and terminate at the rail in eyes to which the dead-eyes or rigging screws are shackled. In steamers, the rigging often sets up to the deck, inside the rail.

The necessary spread for the topmast-shrouds is given by the top, the dead-eyes or rigging-screws being secured to iron rods called "futtock-shrouds" which shackle to a band on the lower mast below the bibbs.

Similarly, to increase the spread of the topgallant rigging, the topmast cross-trees are made with long arms into the ends of which the topgallant shrouds are clamped. In the same way, the arms of the "jack" act as spreaders for the royal shrouds.

The spread for the jib-guys is given by the "whisker-booms" hooked to the bowsprit-cap and extending out on either side, while the "dolphin-striker," projecting below the bowsprit-cap, gives a favorable lead to the martingales and head stays.

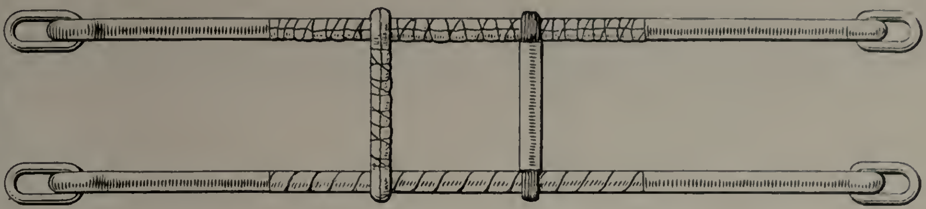
Before the rigging is sent aloft, small blocks of wood, rounded and covered with canvas, are secured on top of the trestle-trees. These are the "bolsters" designed to keep the rigging from sawing across the edge of the trestle-trees.

LOWERMAST HEAD. (Plate **26**.)

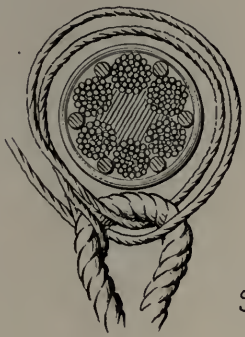
The Pendants go over first. These are fitted "straight"; that is to say, the forward pendants starboard and port are in one, leading straight across, the forward and after leg on each side being spanned together forming a square eye which fits down snugly over the bolsters.

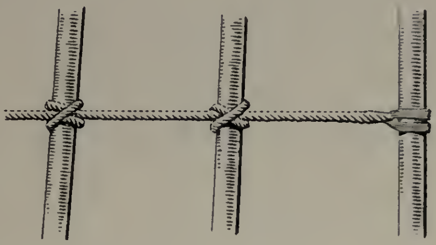
The Shrouds are fitted with eyes and go over the mast-

Plate No. 24.

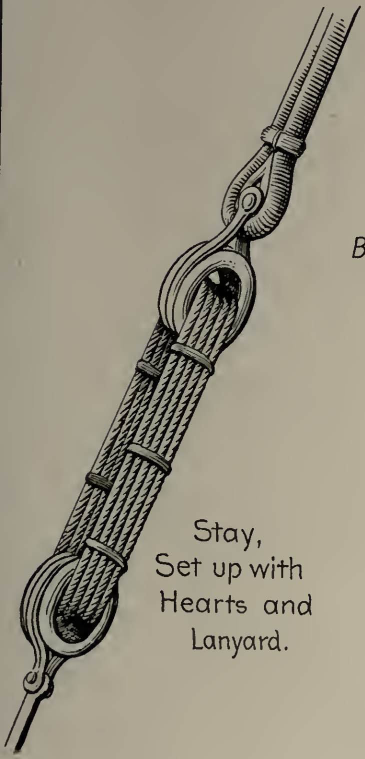


Lower Mast Head Pendants.

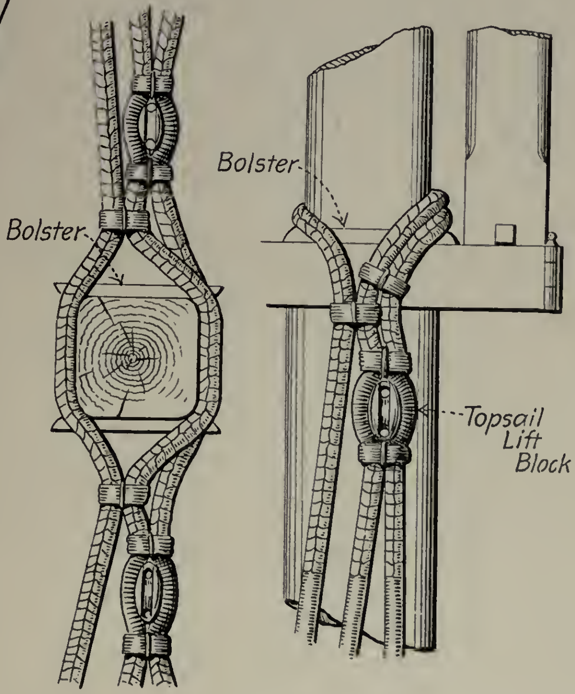




Securing Ratlines to Shrouds.



Stay,
Set up with
Hearts and
Lanyard.



Topmast Rigging Fitted "Straight".

FITTINGS OF STANDING RIGGING.

head in pairs, the two legs of a pair coming down on the same side. The forward pair starboard goes over the first, then the forward pair port; and so on.

The shrouds set up to the rail, the deck, or to the "channels" as already described. Fig. 1, Plate **25**, shows a method commonly used in modern ships. Formerly they were set up with dead-eyes and hemp lanyards, and the use of such lanyards was considered of especial importance with wire rigging because of the "give" which came from their use. In recent ships, not only the shrouds but most of the other standing rigging is set up with rigging-screws, which, although entirely lacking in "give," seem to be satisfactory when strong and well secured.

The Lower Stays go over with collars formed of two legs lashing together abaft the mast with "lashing-eyes." The fore- and main-stays are double, the mizzen stay single.

In all cases where two stays go over the masthead together, their collars are seized together and go over as one.

The fore-stays set up to an iron strap around the bowsprit, and the main-stay to iron rods passing through to the berth deck on each side of the foremast. Formerly these stays were set up by lanyards and hearts, but rigging-screws are now used.

The mizzen stay sets up "on-end" to a strap around the mainmast just above the main fife rail.

On many modern ships, the lower shrouds and stays are shackled to a band around the mast, instead of going over the masthead. This is usually the case in men-of-war fitted with military tops.

Other fittings of the lower masthead are shown in Plate **26**.

THE TOPMAST HEAD. (Plate **27**.)

Topmast Pendants are shackled to bolts in the trestle-trees and fitted with thimbles and links in their lower ends.

Topmast Shrouds are best fitted like the lower shrouds, in alternate pairs starboard and port; but in some ships they are fitted "straight," a starboard and port shroud in one, running over the masthead from side to side. In this case, two shrouds, one forward and one abaft, are seized together on each side to form an eye enclosing the masthead. This method is not as strong as the other one and is not to be recommended.

The topmast shrouds set up to the rim of the top, usually with dead-eyes and lanyards, support being given from below by the "futtock-shrouds," running from the top-rim to a band on the lower mast.

Topmast Backstays are fitted in pairs like lower shrouds and go over the masthead in the same way. They lead down to the rail of the ship or to the channels, abaft the lower shrouds, and set up with dead-eyes and lanyards or with rigging-screws.

Topmast Stays are double and fitted like lower stays. The fore reeve through sheaves on the side of the bowsprit and set up with hearts and lanyards or with rigging-screws at the bows. The main reeve through sheaves in the after part of the fore trestle-trees and set up on deck to heavy bolts abaft the foremast.

The Mizzen Topmast Stay is single and sets up to a bolt in the main top.

On most steamers and on some recent sailing ships, the fore and main topmast stays are single as well as the mizzen.

On ships which carry no sail and have only light topmasts, the topmast shrouds and stays are single and shackle to a band around the topmast head.

The Jib Stay is fitted like the fore topmast stays and goes over the masthead with them. It reeves through the inner sheave in the outer end of the jib-boom, thence under a cleat on the dolphin-striker, and sets up at the bow with a heart and lanyard or with a rigging-screw.

TOPGALLANT MASTHEAD. (Plate 27.)

The Topgallant Rigging is fitted to a composition funnel through which the mast can be lowered for sending down, the funnel and rigging being left above the topmast-cap ready for pointing the mast through when it is sent up.

The Topgallant Stay is single, with an eye fitting snugly around the funnel. The Flying-Jib Stay is fitted in the same way and goes next to the fore topgallant stay, the collars of the two stays being seized together. The fore topgallant stay reeves through the outer sheave in the jib-boom,

Plate No. 25.

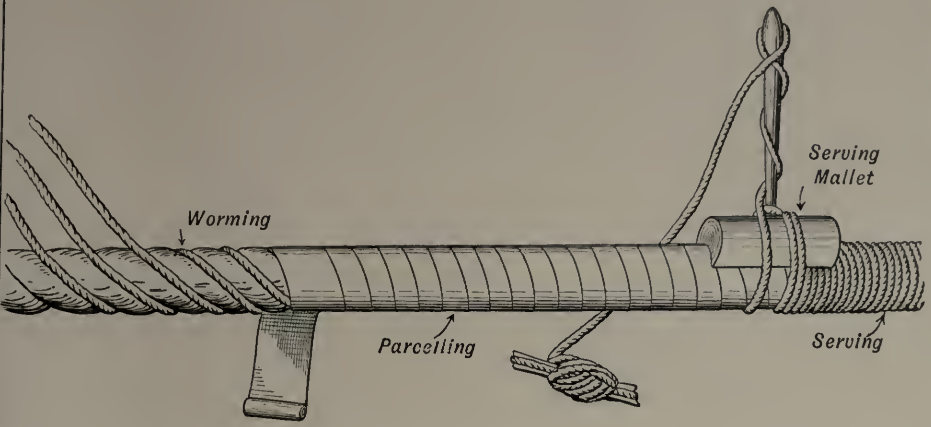


Fig. 1. Worming Parcelling and Serving.

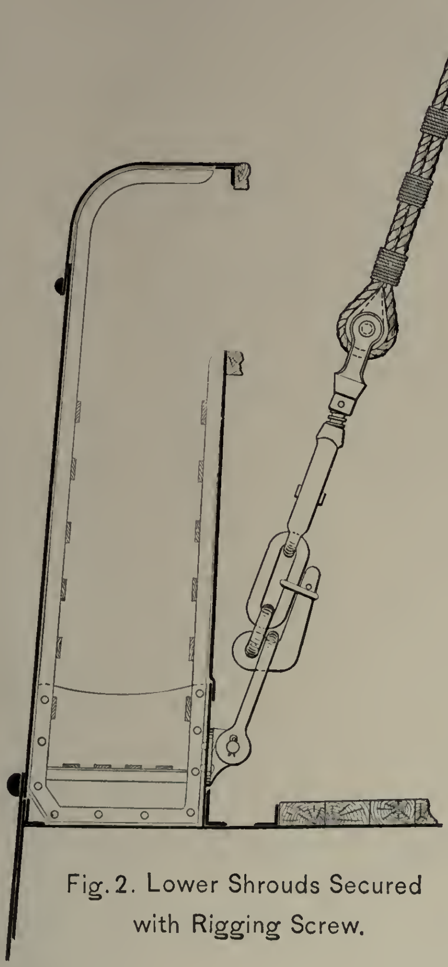


Fig. 2. Lower Shrouds Secured
with Rigging Screw.

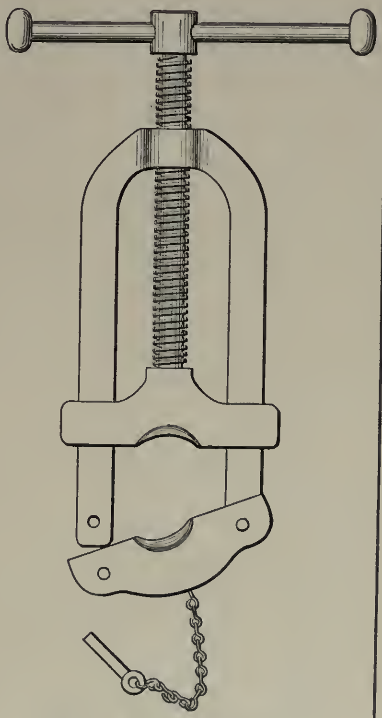


Fig. 3. Rigger's Screw.

FITTING RIGGING.

the flying-jib stay through the inner sheave in the flying jib-boom and both set up in the head (or to the bow) with hearts and lanyards or with rigging-screws. The main topgallant stay reeves through a fairlead in the after part of the fore cap, and the mizzen through a fairlead in the after part of the main cap, and set up in the tops.

Topgallant Shrouds are fitted in pairs like the lower and topmast shrouds, the eyes fitting snugly over the funnel. The legs clamp into the horns of the cross-trees, which act as spreaders, then lead over an iron bar called the "futtock staff," which is covered with leather and seized inside the topmast rigging below the masthead, then to the top, where they set up with dead-eyes and lanyards.

Topgallant Backstays are single and go over the funnel with snugly-fitting spliced eyes. They lead to the side of the ship, where they set up with lanyards and dead-eyes or with rigging-screws, to the channels or to channel plates on the rail.

ROYAL MASTHEAD. (Plate **27**.)

The Royal Stays are spliced around thimbles which are fitted to bolts on the forward part of a band around the royal masthead.

The fore royal stay leads through the outer sheave in the flying jib-boom, under a cleat on the dolphin-striker, and sets up in the head or to the bow. The main royal stay reeves through a chock in the after part of the fore topmast trestle-trees and sets up in the fore top. The mizzen royal stay reeves through a sheave in main topmast trestle-trees and sets up in the main top.

The Royal Shroud and Backstay are in one, reeving through an eye-bolt on the side of the royal band with a seizing just below the bolt to form an eye. The shroud then leads through an eye in the end of the jack and sets up in the top, while the backstay goes direct to the channels or the rail, where it sets up like the topgallant backstays.

THE RIGGING OF THE BOWSPRIT. (Plate **27**.)

Bobstays, of chain or wire rope, shackle to bolts at the cut-water and set up with hearts and lanyards or with rigging-screws under the outer end of the bowsprit.

Bowsprit Shrouds, of chain or wire-rope, shackle to bolts on the bow and set up with hearts and lanyards or with rigging-screws to the side of the bowsprit.

JIB-BOOM. (Plate **27**.)

The Jib-Guys, of wire-rope, shackle to a band on the jib-boom end, go over the end of the whisker-boom with a cringle, and set up with hearts and lanyards or with rigging-screws to the bow. In ships having no whisker-booms, the foretack bumpkin sometimes acts as a spreader for the guys. Or a spreader may be fitted expressly for them.

The Jib Martingale Stay, of chain or wire, shackles at one end to a band on the jib-boom and at the other to a band on the dolphin-striker. It is tautened by setting up the *back-ropes*.

The Foot-ropes are fitted with eyes in both ends, the outer ends seized to the guys just outside the shackle on the boom, the inner ends to bolts in the bowsprit cap.

FLYING JIB-BOOM. (Plate **27**.)

The Flying Jib-Guys, of wire, shackle to a band on the end of the flying jib-boom, reeve through a thimble strapped around the whisker-boom end, and set up with hearts and lanyards or with rigging-screws to the bow.

The Flying-jib Martingale, of wire, shackles to a band on the end of the bow, reeves through a hole or sheave in the dolphin-striker, and sets up at the bow.

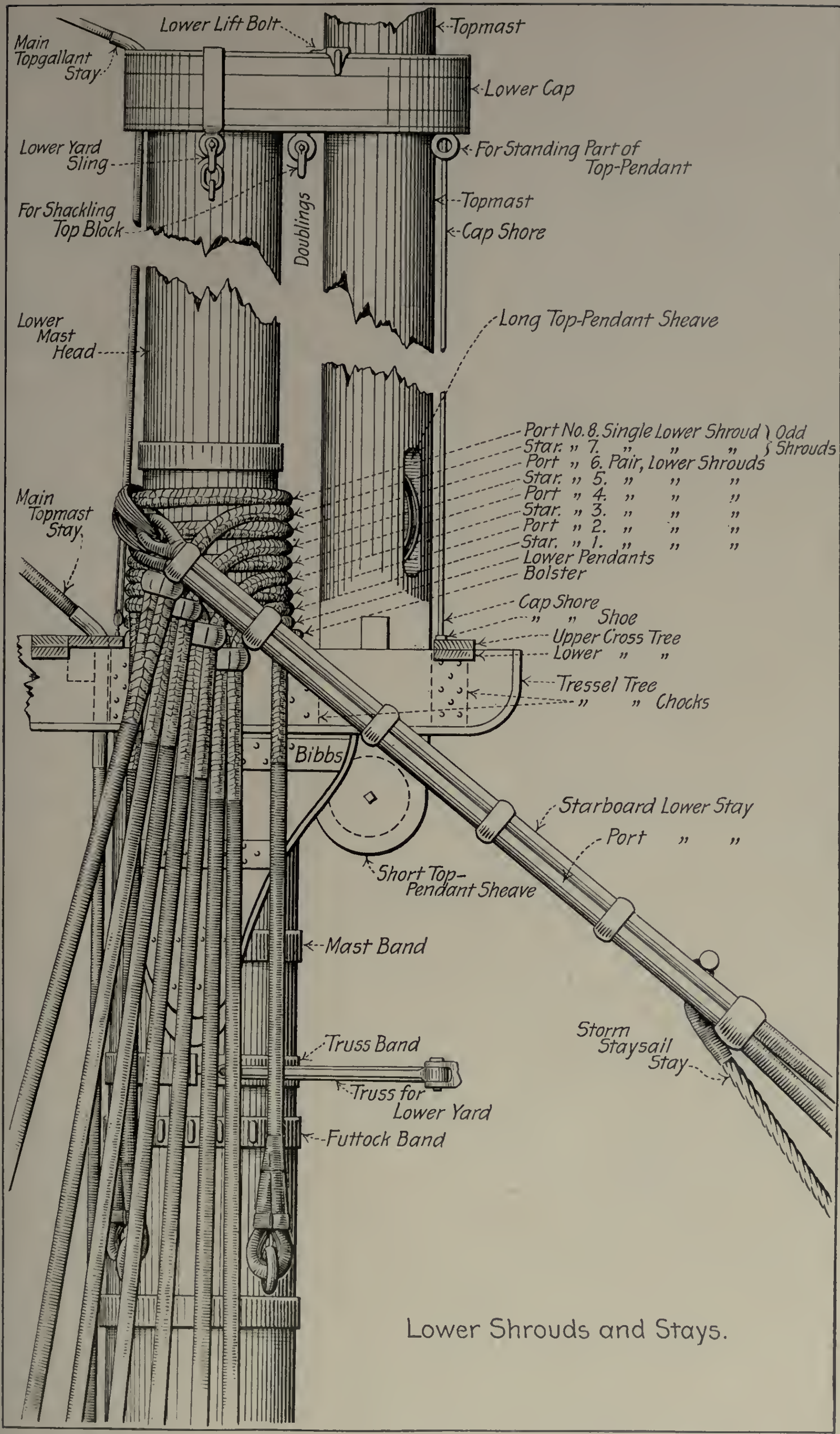
The Foot-ropes, fitted with an eye in each end, are seized at one end to the flying jib-guy close to the shackle, and at the other end to the jib-guy.

WHISKERS AND DOLPHIN-STRIKER.

The Whisker Jumpers, of wire, go over the end of the boom with an eye-splice and set up on-end to a bolt in the cut-water.

The Back-ropes, of wire or chain, shackle to a band on the dolphin-striker and set up at the bow with hearts and lanyards or with rigging-screws.

Plate No. 26.



LOWER MAST HEAD.

§ IV. RIGGING SHIP.

It is assumed that the lower masts, lower trestle-trees, cross-trees, tops, and bowsprit are in place and that the standing rigging has been cut and fitted in the rigging-loft. The bowsprit is secured first of all by setting up the bobstays and bowsprit shrouds. These are triced up by single whips (called in this and similar cases "girtlines") from the bowsprit cap, and set up by their rigging-screws or lanyards. With a lanyard, a purchase, usually two-fold, is needed to furnish the necessary power for setting up. This purchase may be led in any convenient way, but should be kept as nearly as possible in line with the proper lead of the lanyard.

To SEND UP THE LOWER RIGGING.—This is done by means of two girtlines on each side, the block of one hooking to a strap around the tenon at the masthead, that of the other to a strap toggled through a hole in the planking of the top outside the lubber's-hole.

The pendants are sent up first, and gotten over the masthead and fitted down into place by men stationed in the top. The shrouds go up in pairs, fitted as already described, the forward pair starboard first, the forward pair port next, and so on. The ends of the long girtline (the one hooked to the top), are knotted together and toggled between the two shrouds, from *out in*, and at such a distance below the eye that when the toggle is as high as it will go the crown of the eye will be above the tenon of the mast. The shrouds are then swayed aloft. As the eye comes up, it is pointed through the lubber's-hole, and the short girtline (the one from the tenon), is toggled between the shrouds just below the eye-seizing, from *in out* (Plate **29**). This girtline is worked in the top. By the aid of the two girtlines the men aloft slip the eye of the shrouds over the masthead, where it is beaten down snugly into place by heavy wooden mauls. The other shrouds are sent up and beaten down in the same way.

The stays are sent up by the girtlines from the masthead, which are dipped down through the lubber's-hole and bent to the stay at the crotch, the starboard girtline being stopped along the starboard leg, the port one along the port leg. A whip from the forward side of the tenon may be used, if necessary, to take the weight of the stays. The lashing for the legs is passed abaft, forming an eye around the masthead above and outside of, the shrouds (Plate 26). The next thing to be done is to "stay" the mast; viz., to give it the amount of rake determined upon, if any, and to set up the shrouds and stays. A heavy purchase is used from a strap at the masthead leading well forward, and pendant tackles are hooked to the legs of the pendants, those from the after legs leading aft and those from the forward legs, forward. The wedges are eased up if necessary, and the mast stayed either vertically or with the desired rake, this being fixed by a plumb-line from the masthead to the deck at a calculated distance from the mast. The wedges are then driven in and the stays and shrouds set up by their rigging screws. The stays are set up first, then the shrouds in succession, from forward aft, corresponding pairs starboard and port being set up together. Where dead-eyes and lanyards are used instead of screws, the necessary power for setting up is gained by purchases as in Plate 29. To avoid injury to the lanyard, the purchase is hooked to it by a strap and toggle, as shown in the plate. As the eyes of the rigging require time to settle down into place, the stays and shrouds will gradually slack after the original setting up, and should be set up again later, perhaps more than once, the final setting up being done if possible in warm dry weather.

The lower cap is sent up by the girtlines and placed by the men in the top with its round hole over the hole for the topmast in the forward part of the trestle-trees.

This and the subsequent operations of rigging ship are differently performed by different riggers. The methods which follow are from the practice of a rigger of many years' successful experience, and while perhaps no better than others that have been suggested, they are probably as convenient as any.

To GET A TOPMAST IN AND SEND IT UP.—Tow the mast alongside with the head forward, say on the starboard side. Pass a long strap, of 5- or 6-inch stuff, through the fid-hole, and bring the bight up toward the head of the topmast for perhaps two-thirds the length of the mast. At this point put a short double strap around the mast, bringing the two bights through the long strap, as in Plate 30, Fig. 1. Overhaul down the starboard pendant-tackle and hook it to the straps as shown. Sway the mast on board and up and down the lower mast. As the topmast is usually longer than the drift between the deck and the top, it will probably be necessary to sway the topmast-

Plate No. 27.

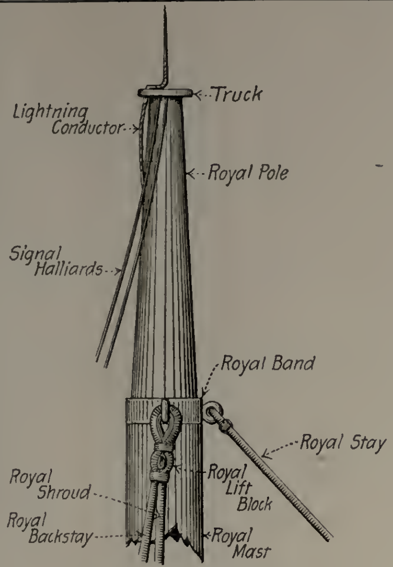


Fig. 3. Royal Mast Head.

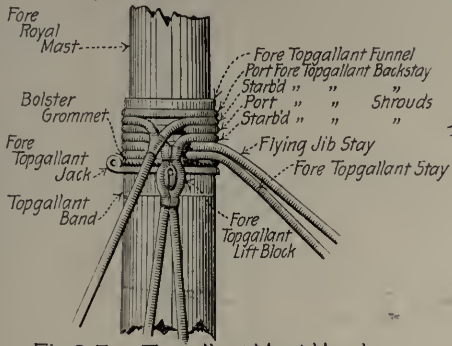


Fig. 2. Fore Topgallant Mast Head.

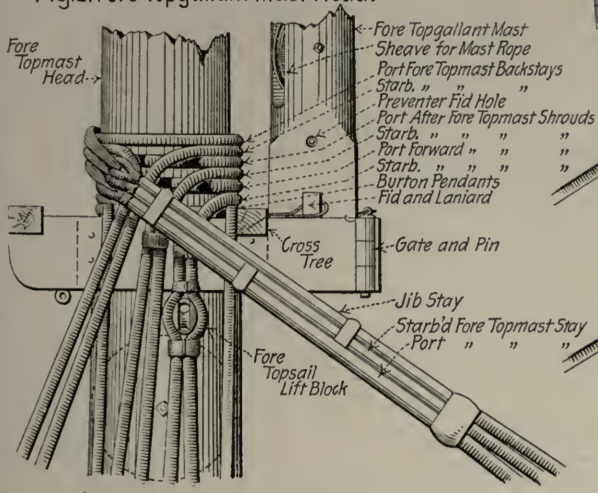


Fig. 1. Fore Topmast Head.

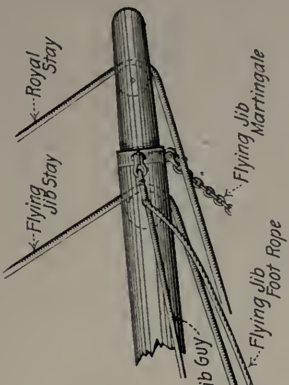


Fig. 6. Flying Jib-Boom.

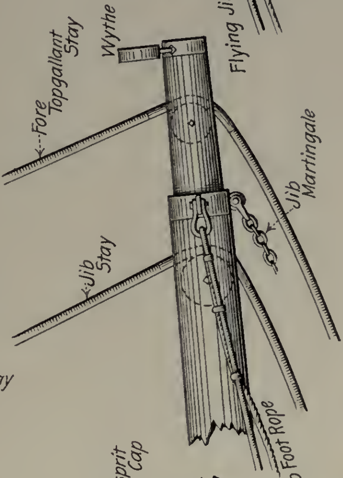


Fig. 5. Jib – Boom.

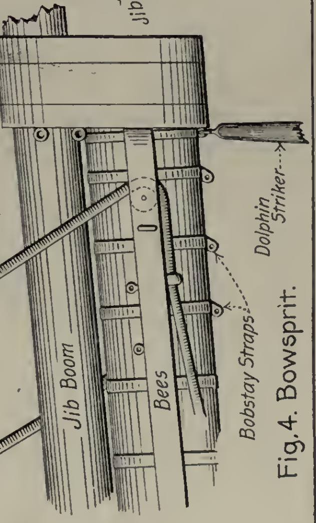


Fig. 4. Bowsprit.

STANDING RIGGING

head up forward of the top-rim at first, and then to lower the heel down through a hatch or scuttle to admit of pointing the head through the square hole in the lower trestle-trees. A scuttle is usually fitted for this purpose immediately forward of the lower mast. Having pointed the mast in this way, sway it up high enough to admit of closing the scuttle, and rest the heel of the mast on deck. In this position it is perfectly secure provided the head is pointed as has been described. If it happens that the mast is shorter than the drift from the deck to the top, its head may be lashed temporarily to the lower mast. Now put a short strap through the fid-hole (Fig. 2, Plate **30**) and hook the port pendant-tackle on this. At the same time shorten in on the strap of the other pendant-tackle. Sway up through the trestle-trees and the lower cap, lash the cap to the masthead, and proceed to ship it.

To ship the lower cap.—The cap is hung from the topmast head by lashings long enough to admit of slueing it freely (Fig. 3, Plate **30**) and the topmast is swayed up until the cap rises above the tenon of the lower mast, when it is cut around square with the tenon and fitted down in place by lowering away the topmast. The topmast may be slued if this is found necessary for placing the cap fair. As soon as the cap is secured, the top-blocks are sent aloft and hooked in place, the top-pendants rove in their places (through the blocks at the cap and the sheaves in the heel of the mast) the top-tackles hooked, and the mast hung by these, the pendant-tackles being gotten out of the way. The topmast is then swayed up three or four feet above the cap.

To send up the topmast cross-trees.—Lash two girtline blocks to the tenon of the topmast, lead the girtlines down abaft and bend them to the after horns of the trestle-trees (which are in one with the cross-trees), stopping them to the forward horns along the upper side. Bend on also a guy from aft. Sway up and land the cross-trees on the lower cap, canting them up and down as much as may be necessary, and lash them there with the forward chock (gate) of the trestle-trees resting against the after side of the topmast (Plate **29**). Having secured them from slipping, remove the girtline blocks and lower away the topmast until its head is low enough to admit of cutting the cross-trees forward and squaring them up over the topmast-head. Then sway up, land the trestle-trees on the hounds and beat them down into place.

To RIG THE TOPMAST.—By means of girtlines, send up and fit in place the composition funnel for the rigging, beating it well down in place upon the trestle-trees; then proceed to send up the shrouds, backstays, and stays, and get them in place by practically the same method as that used with the lower rigging. The mast is then swayed up and fidded, and the rigging is set up.

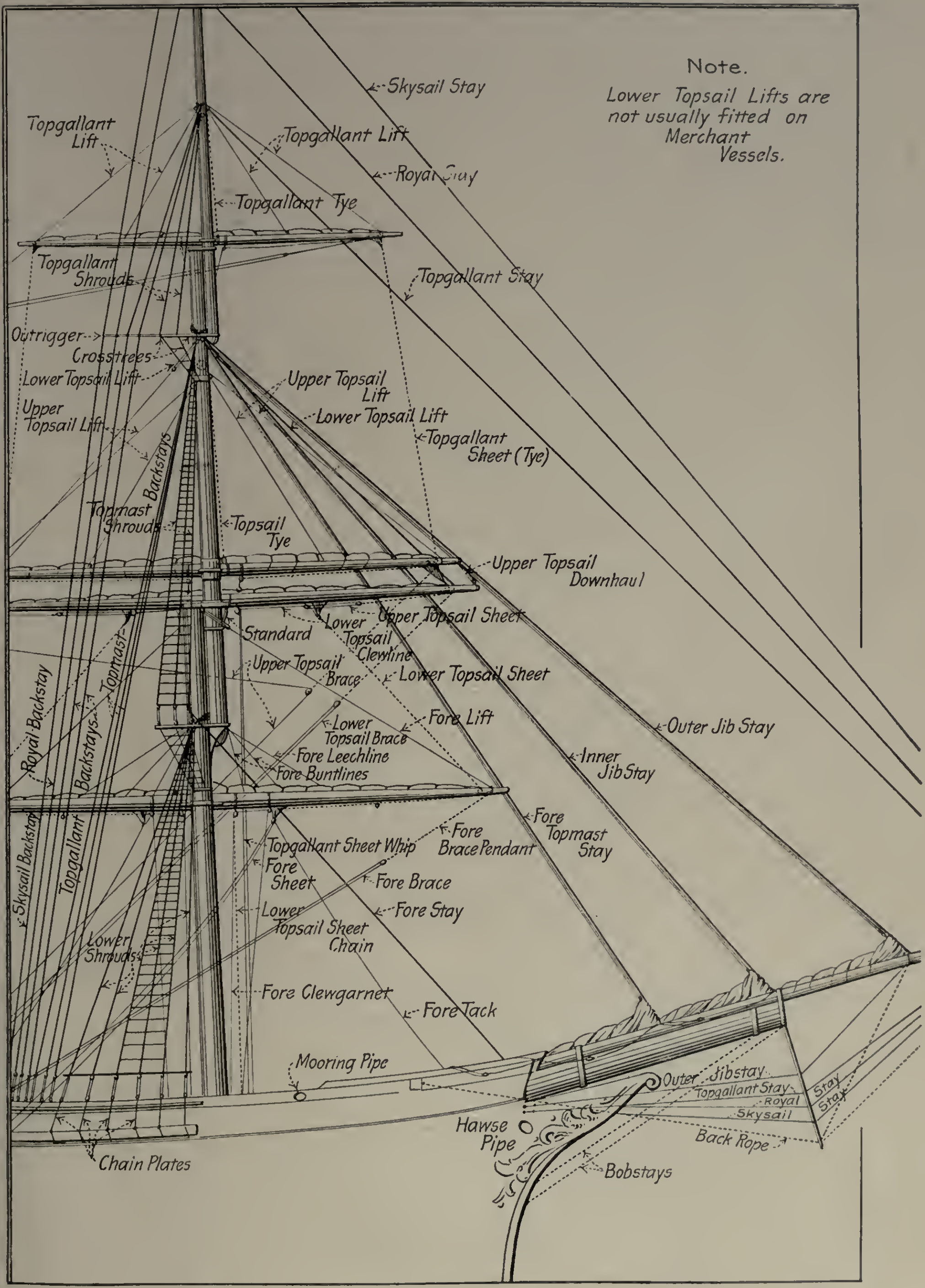
In fidding the mast, as soon as the fid-hole is open above the trestle-trees, shove in a good iron bar as a preventer. The mast often sticks when nearly up, and in the very heavy heaving required for the last inch or so, there is danger that something will give way.

The topmast rigging usually sets up with dead-eyes and lanyards, even on ships where rigging-screws are used for the lower rigging, it being considered necessary to preserve here something of the "give" that comes from the use of a hemp lanyard. The rigging is set up by a purchase like that shown in Fig. 3, Plate 29, the routine observed being practically identical with that of setting up the lower rigging. The stay is rove as has been described in the preceding section, and is set up before the shrouds.

To SHIP THE TOPMAST CAP.—This may be shipped by the help of the topgallant mast, the method used being identical with that already described for shipping the lower cap. But a simpler method is to rig a derrick, of a capstan bar or a light spar of some kind, lashed up and down the topmast abaft and held off clear of the mast by a block rather thicker than the rim of the cap, thus leaving space for fitting the cap down into place between the derrick and the mast. Girtline blocks are secured at the head of the derrick, and the girtlines are used to send up the cap, which is fitted in place without difficulty.

To GET IN THE MAIN YARD.—It will be convenient to do this before sending up the mizzen topmast, which is thus available for a derrick. It is stepped in a shoe close out to the rail immediately forward of the main rigging, to the forward swifter of which it is lashed;—the lashing, however, being passed aft from shroud to shroud with a turn around each, in order that all may divide the strain. This strain is not great, as the shrouds serve only to steady the derrick. A light spar, like a royal yard or a flying jib-boom, is lashed across from the derrick to the main mast, to take the thrust upon the derrick when the yard

Plate No. 28.



Fore Mast and Head-Booms of a Modern Sailing Ship.

is swung around and hauled in, as hereafter described. The derrick is supported by a topping-lift from the lower masthead, consisting of a good two- or three-fold purchase, and steadied by a guy leading aft outside the rigging and another leading to the foretopmast head. The yard is towed alongside with the port yard-arm forward. A three-fold purchase is used from the derrick head to the slings of the yard, and the jeer-fall, hooked in its place at the lower masthead, is overhauled down and hooked also to the slings. Steadying lines are used on both yard-arms. The fall of the derrick-head purchase is taken to the winch, and the yard is swayed up, the slack of the jeers being taken in at the same time. When the yard is well above the rail, the forward yard-arm is swung around under the main stay and across the deck, the jeer-falls are manned and the derrick-head purchase is eased away, and the yard swings in square across the deck, hanging by the jeers. It may be landed on the rail or sent aloft at once.

To SEND UP THE MAIN YARD.—Overhaul down the top-burtons and hook them to the quarter straps, reeve the braces, and hook a fore and aft tackle to the slings from forward. Sway up by the jeers, keeping control by the top-burtons, braces, and fore and aft tackle. Hook the slings and key the truss. Reeve and haul taut the lifts.

Shift the derrick forward and get in the fore yard in the same way.

The fore and main yards being in place, the problem of getting in the other spars is much simplified.

To GET IN A TOPSAIL YARD.—Tow the yard alongside, say on the starboard side with the port yard-arm forward. Lash a heavy single block at the topmast head and reeve a good line (say a 5-inch), taking the end down to the slings of the yard and lashing it out to the forward quarter. Brace up the main yard by the port brace and secure it by hauling taut both lifts and by hooking and hauling taut a top-burton on each yard-arm. Put a strap on the starboard lower yard-arm and hook there the upper block of a two-fold purchase, hooking the other block to the forward quarter of the topsail yard near the point to which the hawser is stopped out. This purchase need not be very heavy, as it is designed, not to lift the yard, but to hold it off, preventing it from swinging in too fast as the lower yard-arm rises above the rail. Protect the ship's side well by skids. Take the hauling part of the hawser to the winch and sway up. As the yard rises, it is kept off by the yard tackle until the lower yard-arm is high enough to clear the rail, when it is eased in and landed in the gangway, the lower yard-arm being dragged aft in a shoe to prevent injury to the deck.

To SEND UP A TOPSAIL YARD.—Hook the upper block of a pendant tackle to a strap at the topmast head and the lower block to the slings of the yard. Overhaul down both top-burtons and hook them to the quarters of the yard, and hook a fore and aft tackle from forward to the slings. Coil the lifts just outside the slings and stop them to the sling-band. Man the pendant tackle and the port top-burton, get the yard up and down and sway aloft, taking down the slack of the lower (starboard) top-burton, and holding the yard well forward with the fore and aft tackle. As the slings rise well above the lower stay, pull up on the starboard burton and begin to sway across, squaring the yard and landing it on the cap with both burtons taut. Pass the parrel or key the truss. Reeve and haul taut the lifts, lash the quarters of the yard to the topmast shrouds, and send hands out to reeve lines through the brace blocks for reeving off the braces. Reeve the tye and hook and haul taut the halliards.

To complete the description of handling heavy spars, it will be convenient to add here the following:

To SEND DOWN TOPSAIL YARDS.—Hook a pendant tackle and two top-burtons as has been described for sending up, and take the weight of the yard by them. Unhook the halliards, either sending them down or hooking the fly-block to a strap at the cross-trees. Unreeve the tye. Bend the top bowline to the slings for hauling the yard forward. Lash the quarters of the yard to the topmast rigging and unreeve the lifts and braces. Cut the lashings and sway up on the pendant-tackle and upper top-burton, which will be the port one if the yard is to be sent down to starboard. Send the yard down and land it in the gangway with the port yard-arm forward.

To SEND DOWN THE LOWER YARD.—Reeve off the jeers, hook the top-burtons to the yard-arms, hook on a fore-and-aft tackle from forward to the slings, unkey the truss, unhook the slings,

Plate No. 29.

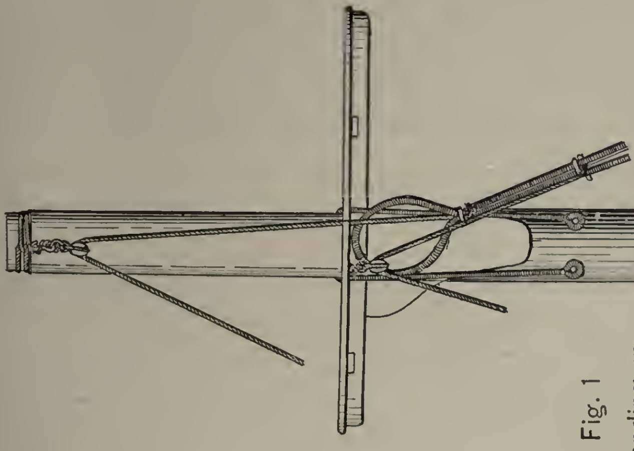


Fig. 1
Sending up
Lower Shrouds.

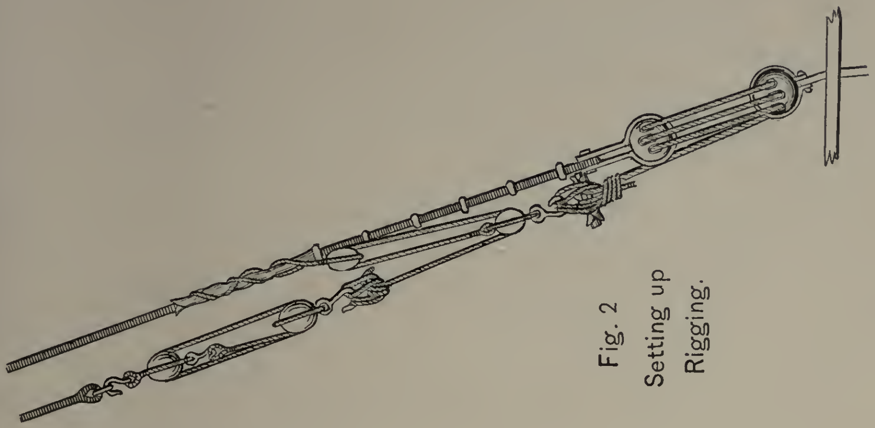


Fig. 2
Setting up
Rigging.

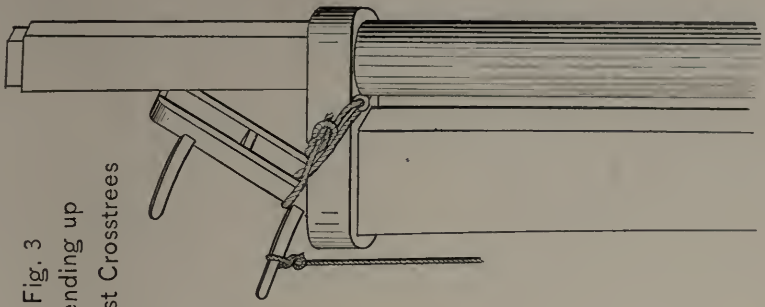


Fig. 3
Sending up
Topmast Crosstrees

RIGGING SHIP.

tend the lifts and braces, haul forward and lower away, landing the yard on the rails.

To HOUSE TOPMASTS.—Reeve off the top-pendants and hook the top-tackles in their ends. Come up the topmast rigging. Sway up and unfid. Lower away until the trestle-trees are just clear of the lower cap.

To SEND OUT THE JIB-BOOM.—The boom is pointed out through the hole in the bowsprit cap and rigged out by a heel-rope, which reeves through a block on one side of the bowsprit cap, through the sheave in the heel of the boom, and clinches to a bolt on the side of the cap opposite the bolt for the block. The head of the boom having been pointed through the cap, the band is fitted on, and the guys and martingale hooked to it. The boom is then rigged out to its place, the heel lashing passed and the rigging set up.

To SEND UP TOPGALLANT MASTS.—Suppose the main topgallant mast is in the starboard gangway with the head forward, and that the topmast cap has been shipped. Hook the topgallant top-block at the cap and reeve the mast rope, bringing the end down through the gate in the trestle-trees, through the sheave in the heel of the mast, through the thimble of a lizard hitched in the royal sheave hole, and up to the topmast cap, where it is clinched to a bolt in the cap on the opposite side from the bolt for the top-block. Man the mast-rope, get the mast up and down and sway it aloft, pointing it through the hole in the trestle-trees and the round hole in the topmast cap. As soon as it is pointed through, the lizard is cast off.

Send up the topgallant rigging (fitted on the funnel) by girtlines from the topmast cap, and place the funnel on the cap by hand. If too heavy for this, sway the topgallant mast up above the cap and use the girtlines from the masthead to land the funnel on the cap, then lower away, cut the funnel forward and square it up. Send up the royal rigging in the same way with the truck stopped to it. Sway up the mast, and fit the truck, the royal band, and the topgallant funnel into place in succession as the mast reaches the proper point for each. Fid the mast, reeve and set up the topgallant and royal rigging.

To SEND UP A TOPGALLANT YARD.—The yard-rope is hooked to the slings and stopped out to the quarter to keep the yard up and down. On men-of-war, where drills with light yards are frequent, a "lizard" is fitted permanently for hauling the yard-rope out to the quarter strap, and in addition to this, a grommet, playing freely on the yard-rope, is slipped over the yard-arm to keep it close in to the yard-rope and prevent fouling as the yard goes up. Preparations for receiving the yard aloft include overhauling the lift and brace for the lower yard-arm to some point at which it will be convenient to put them on when the yard (still up and down) shall have been swayed as high as possible. The upper lift and brace are kept in hand at the cross-trees to be put on when the upper yard-arm reaches that point, the grommet being first taken off. The lift and brace bands having been put on and secured with stops, the lower lift is made fast at the square mark, a turn is taken with the parrel, and the lizard is tended ready for slipping. To sway across, the lizard is slipped and the yard-rope let go on deck. The yard falls across, hanging by the lifts, which, if made fast at the square mark as they should be, bring the yard into place with the slings just clear of the cap.

> With a very long topgallant yard it may happen that when the yard is hoisted as high as it will go (the lizard being jammed up to the jack-block), the lower lift cannot be gotten down to the square mark in the top. The result is that the yard when crossed hangs below the cap. The remedy is to lead the lower lift on deck, man it, and take it in to the square mark at the order *Sway Across!*

TO SEND DOWN A TOPGALLANT YARD, the gear is unbent, the yard-rope stopped out, the stops cut on the band of the lift and brace, and a light "tripping line" from deck bent to the "snorter" on the side on which the yard is to go down.

> The snorter is a short length of plaited rope spliced to an eye-bolt at the yard-arm end and brought in under the eye of the lift and brace. When the yard is up and down, with the lift slack, hauling on the snorter pulls off the lift and brace band.

The yard-rope is manned, the lower lift cleared away and tended, and at the order *Sway,* the yard is canted up and down by running the yard up as high as the lizard will permit. The tripping line and snorter pull off the lower lift and brace, the upper one is taken off by hand, and the yard is lowered, a few hands on the tripping line keeping it clear.

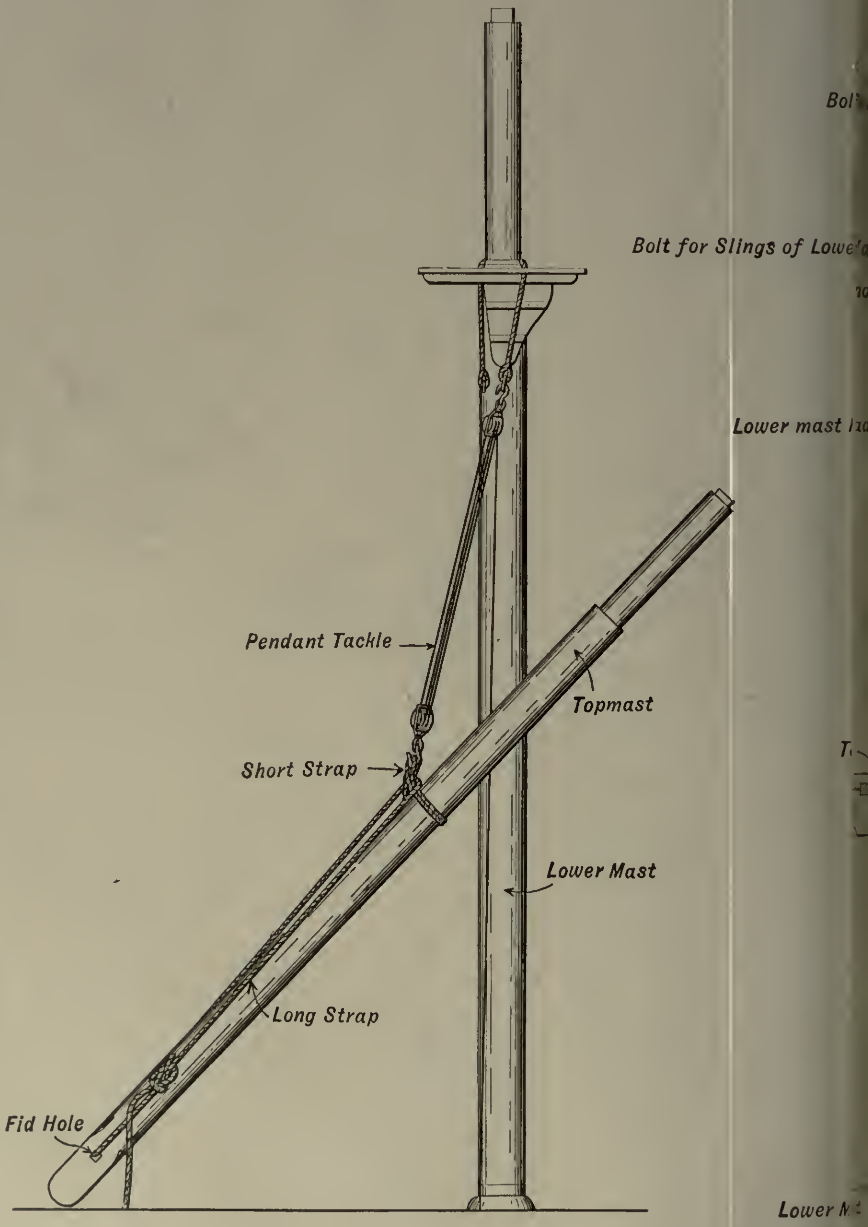


Fig. 1

SENDING UP TOPMAS

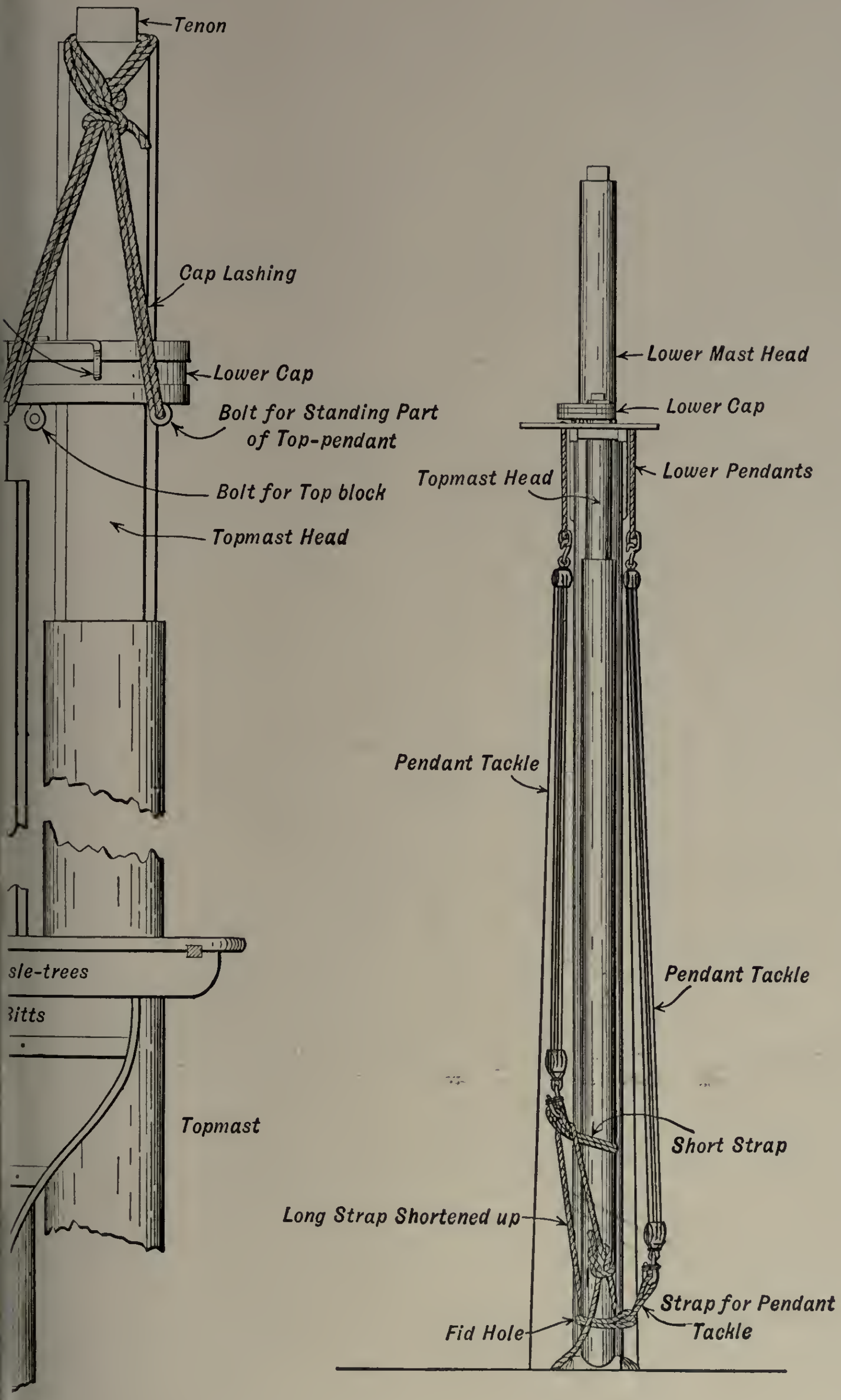


Fig. 3

Fig. 2

HIPPING LOWER CAP.

The royal yards are sent up and down like the topgallant yards.

To SEND DOWN A TOPGALLANT MAST.—Reeve the mast-rope through the topgallant top-block by means of a reeving-line led through the block and down to the deck abaft. The hauling part of this reeving line is manned on deck or in the top. The mast-rope having been rove through the top-block in this way may be hung by a stop from the cross-trees, leaving a few fathoms of slack on the standing part, which is then rove by hand through the sheave in the mast, through the thimble of a lizard, and clinched to a bolt in the cap opposite the bolt for the block. Come up the topgallant and royal rigging, sway up and unfid the mast, and lower away, landing the topgallant funnel, the royal band and the truck on the topmast-cap, one above the other. As the royal sheave-hole comes below the cap, pass the lizard through the hole and around the mast-rope, taking care to hitch it securely. Lower away and land the mast on deck with the head forward. Lash the rigging securely at the topmast cap.

CHAPTER IV.

SAILS AND RUNNING GEAR.

§ I. SAILS.

Sails are made of canvas, which may be of flax, hemp or cotton. The sails of ships are always of flax, those of boats and small yachts usually of cotton. Cotton canvas is used also on ship-board for a variety of purposes, such as awnings, wind-sails, hammocks, tarpaulins, &c.

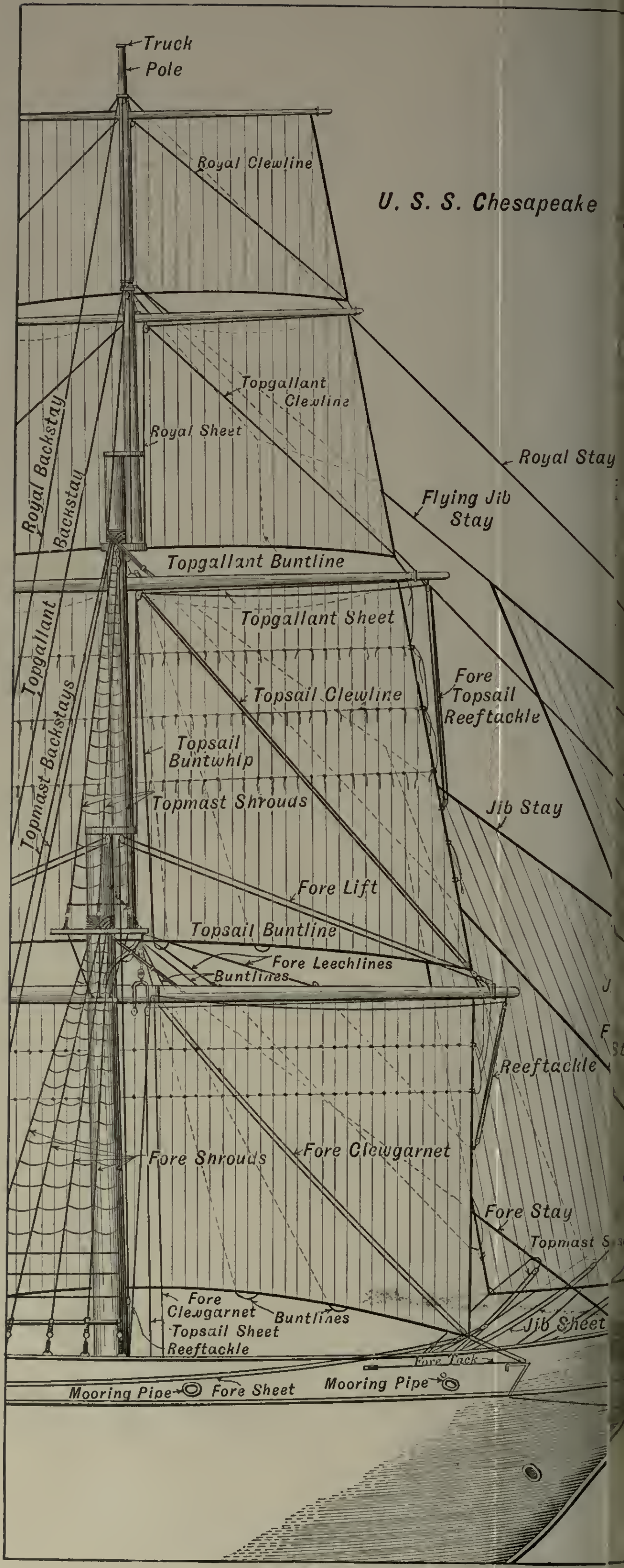
Canvas is manufactured in long strips or cloths, varying in width from 16 to 24 inches for flax, and from 20 to 42 inches for cotton, and in lengths of from 40 to 80 yards. The cloths are made up in rolls called bolts.

Variations in weight, strength and fineness are indicated by numbers running from 1 to 10; number 1 being the heaviest, strongest and coarsest, and number 10 the lightest and finest.

In the United States Navy, canvas is used as follows:

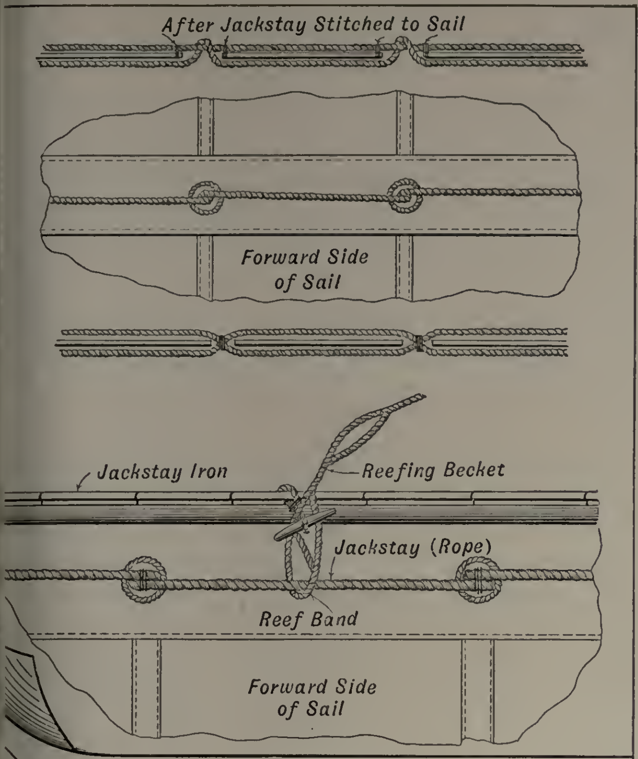
For the sails of ships, flax canvas, 24 inches wide, issued in bolts of 80 yards. For awnings, screens, etc., cotton canvas, 22 inches wide, in bolts of 90 yards. For hammocks and bags, cotton canvas, 42 inches wide, in bolts of 90 yards. For boats' sails, cotton canvas of the variety known as "raven's duck," 28½ inches wide, in bolts of 65 yards.

Good canvas is made of long, strong, clean threads, evenly spun and well twisted and without any mixture of tow. In the heavier grades (Nos. 1 to 3), the threads are double, and in all grades the cloths should be closely and uniformly woven, and with a firm, even selvage. To test a sample of canvas, after examining carefully the character of the texture as to the smoothness and closeness of the weaving, it is well to bore through with a fid, when the threads will break easily if of inferior quality, and resist, with a disposition to stretch before yielding altogether, if of good strong staple. A few threads may be drawn and examined as to length, smoothness and freedom from tow; and finally, if two samples are to be compared, similar strips from the two may be knotted together and tested by hanging weights from them to determine which is the stronger.

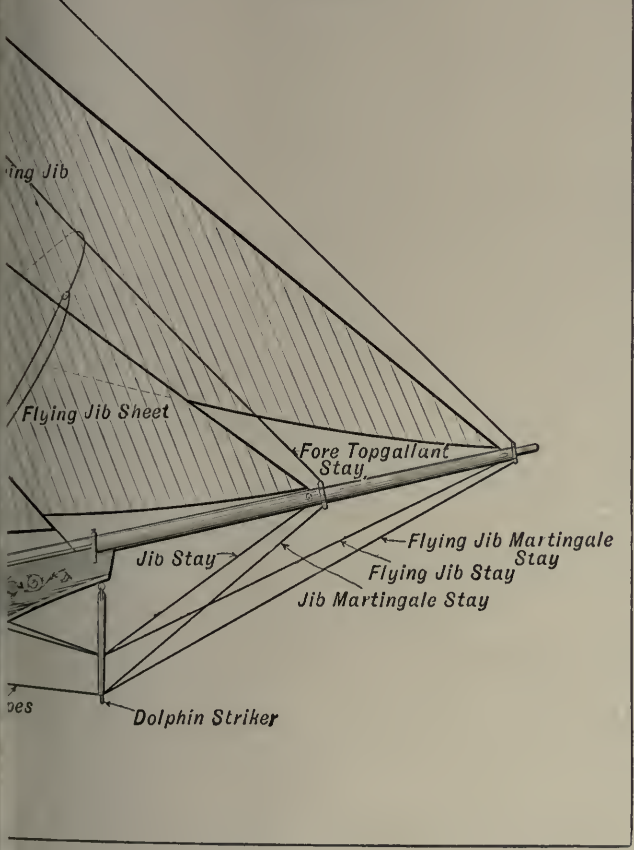


FOREMAST AND HEA

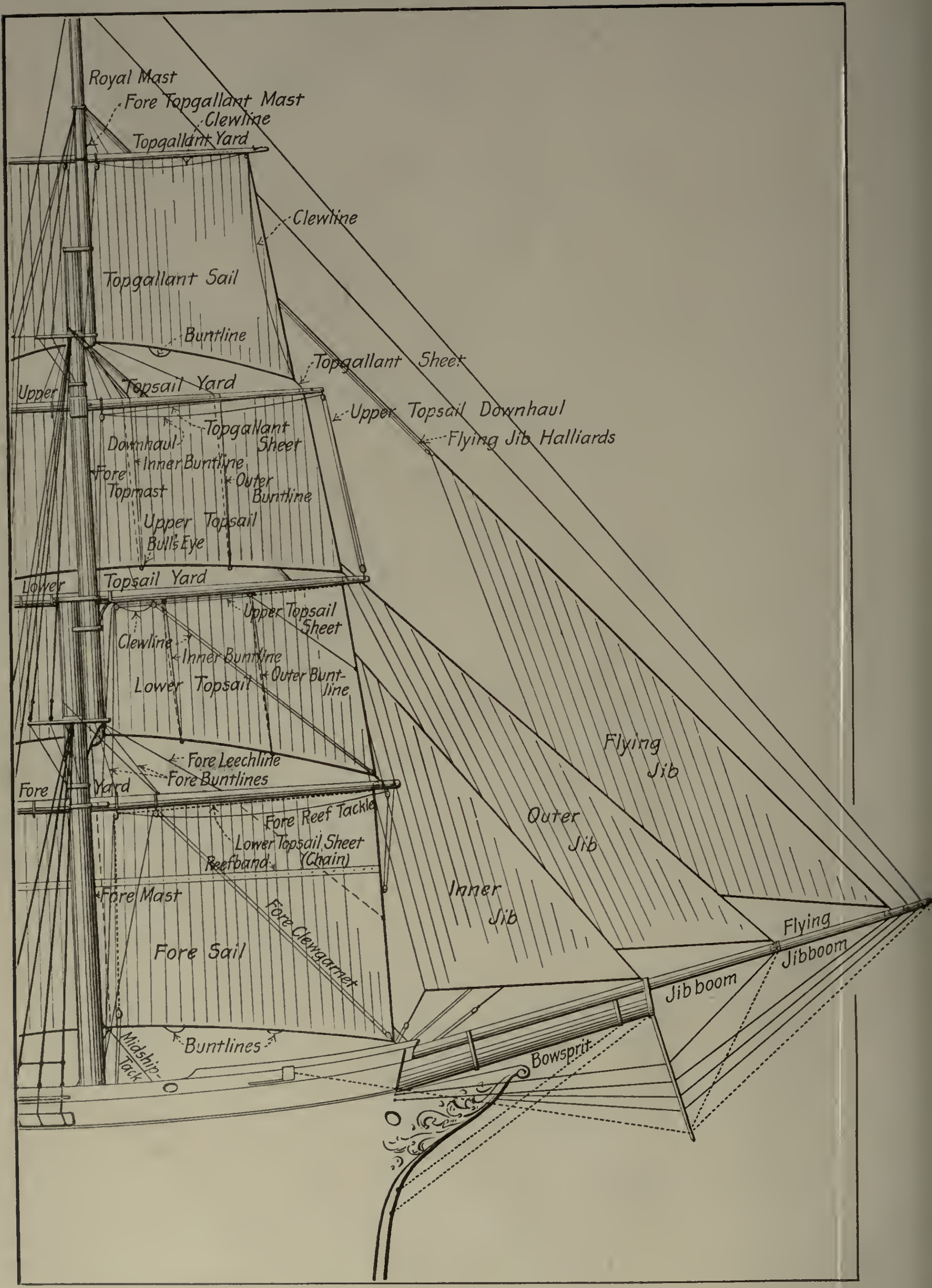
31.



"French Reef"



S OF SAILING SHIP.



FORE MAST AND HEAD-BOOMS OF A MODERN SAILING SHIP, SAILS SET.

An 80-yard bolt of No. 1 flax canvas, 20 inches wide, should weigh about 75 lbs. and the successive numbers from this to No. 10 should diminish by about 5 lbs. each, a bolt of No. 2 weighing 70 lbs., one of No. 3, 65 lbs., and so on.

The following numbers are commonly used for the sails of a full-powered sailing ship, the lighter grades specified in each case forming a fair-weather suit of sails, while the heavier ones are bent in anticipation of a stormy passage:

Courses,	Nos. 1 to 3.
Topsails,	" 2 to 3.
Topgallant sails,	" 4 to 5.
Royals,	" 5 to 6.
Topmast staysails,	" 3 to 4.
Jibs,	" 4 to 5.
Other staysails,	" 4 to 5.
Spankers, trysails, &c.,	" 4 to 5.
All storm sails,	No. 1.

The square sails of a ship (Plates **31** and **32**) are the courses (foresail and mainsail), the topsails, topgallant sails and royals. A skysail is sometimes set above the royals. Topsails and topgallant sails may be single or double.

The fore and aft sails are the fore and main trysails, the spanker (which is in reality a mizzen trysail), the staysails, taking their names from the stays on which they are set, and the jibs, which are also staysails, although not so-called. The trysails are called also spencers, and the spanker is often called the driver.

The upper edge of a square sail is called the head, the lower edge, the foot, the sides, leeches, the upper corners the head cringles, the lower corners, the clews.

In the case of a four-sided fore-and-aft sail like a trysail or spanker (Plate **33**) the after edge is the after leech, the forward edge the luff, the upper edge the head, the lower edge the foot, the upper after corner the peak, the upper forward corner the nock, the lower forward corner the tack, the lower after corner the clew.

In a triangular sail (Plate **33**), the edge next the stay is the luff, the after edge the leech, the lower edge the foot, the lower forward corner the tack, the lower after corner the clew, and the upper corner the head.

The details of sails of various kinds are fully shown in Plates **33**, **34** and **35**.

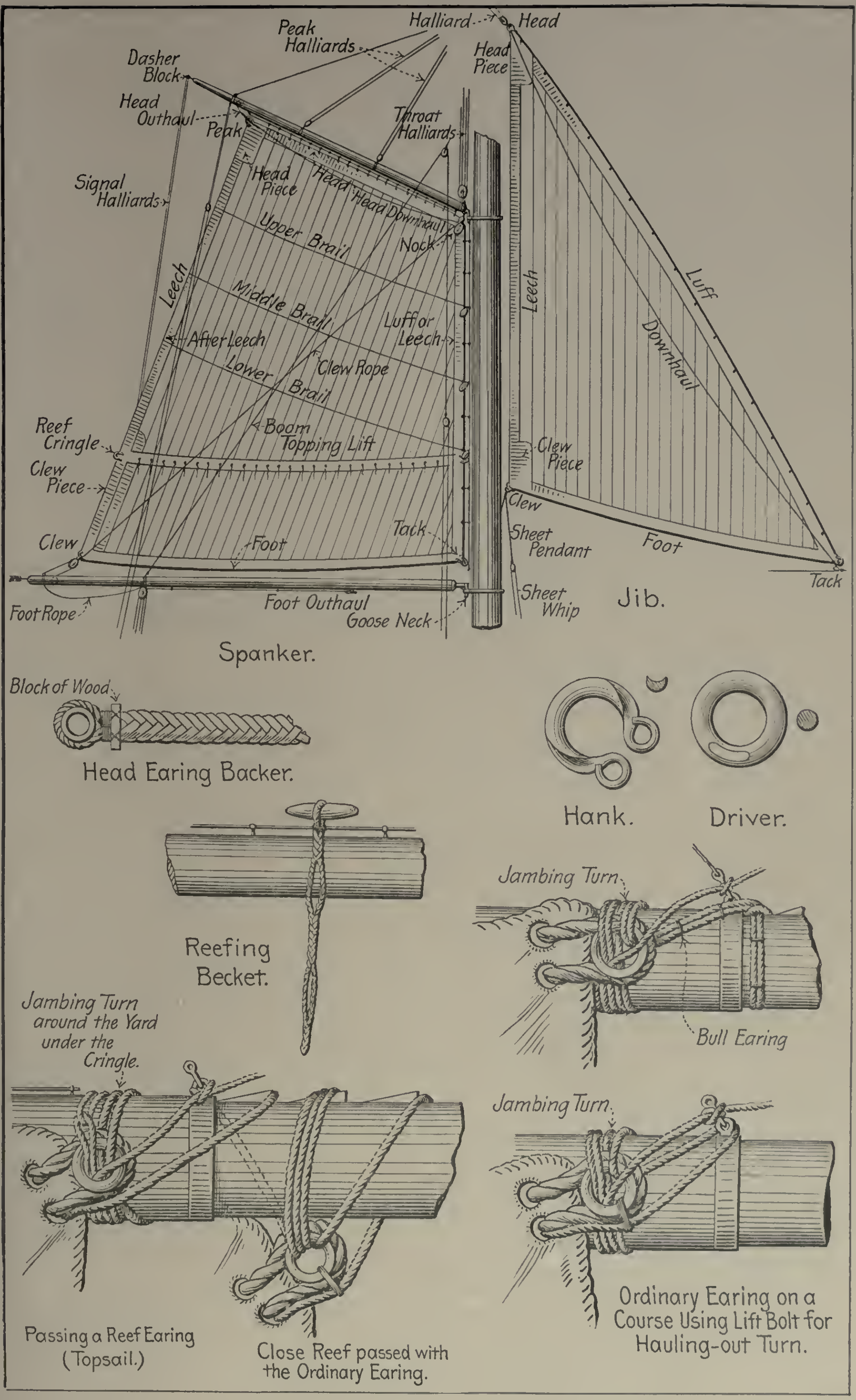
The cutting and making of sails constitute an art in themselves, which it would be beyond the province of this book to attempt to teach. The canvas must be cut with care, not only to economize material in adapting the narrow cloths to the irregular shapes required, but to reduce stretching to a minimum and to distribute such stretch as cannot be prevented, in a way to avoid distorting the sail and allowing it to bag. Canvas stretches very little along the line of the threads of either warp or filling, but may give considerably under a diagonal pull. Owing to the way in which sails are set (being hauled out by their corners), the greater part of the strain to which they are subjected is diagonal, and one of the most difficult points in sail making is to arrange the material in such a way that the cloths may take this strain directly along the threads. When this has been done as far as possible, allowance must be made for the stretch which still remains, and also for the difference in stretching between the canvas and the roping.

The cloths are sewed together with overlapping (double) seams having from 110 to 130 stitches to the yard. The twine used should be of good flax or cotton, spun with from three to eight threads and waxed with pure beeswax.

Sails are hollowed out or roached, on the foot to prevent chafing across stays and on the leech to admit of hauling the successive reef-earings up to the yard clear of each other and clear of the head earings instead of bunching all the cringles on top of each other.

Sails are reinforced at points which are subject to especial strain or chafe. The following strengthening pieces are used in a topsail: Leech and foot linings along the leech and foot; buntline cloths in the wake of the buntlines; reef-tackle pieces running diagonally downward from the reef-tackle cringles; top-linings and mast-linings, in the wake of the top and mast; reef-bands running across the sail at each line of reef points; and a belly-band running across midway between the close reef band and the foot. All of these pieces except the mast and top-linings are on the fore side of the sail.

Plate No. 33.



Spanker.

Jib.

Head Earing Backer.

Hank.

Driver.

Reefing Becket.

Passing a Reef Earing (Topsail.)

Close Reef passed with the Ordinary Earing.

Ordinary Earing on a Course Using Lift Bolt for Hauling-out Turn.

DETAILS OF SAILS AND FITTINGS.

The edges of the sail all around are turned over, forming a hem or tabling several inches wide. The linings and other strengthening pieces are then sewed on, and lastly the bolt-rope. This is of hemp and should be of the best quality, rather loosely laid up to make it soft and pliable, and tarred with the best Stockholm tar. As there is more stretch to the rope than to the canvas, care must be taken to leave a little slack canvas along the edges, as otherwise the canvas, instead of the roping, would take the strain when the sail is set. A common rule is to allow one inch of slack canvas for every foot along the leeches of topsails and canvas, and one inch for every yard along the foot.

The roping of square sails is always on the after side of the sails, that of fore and aft sails usually on the port side.

The clews of sails are fitted in various ways for securing sheets, clew-lines, &c. With courses and topsails, spectacle-irons are now commonly used (Plate **34**), and these are sometimes used with topgallant sails also.

The clews of royals are fitted with toggles to which the sheet is secured by a small eye, while the clew-line is hitched around the clew just above the toggle.

Head-earings, reef-tackles, reef-earings and bowline bridles are attached to cringles on the leech of the sail worked around the bolt-rope and through holes in the sail, as in Plate **18**.

All strengthening pieces are made of lighter canvas than that used in the body of the sail, and should be left rather slack in sewing on.

It may be noted here that in repairing sails which are somewhat worn, a lighter grade of canvas should be used than that of which the sails are made.

Courses usually have two reef-bands, and single topsails either three or four. The reef-bands are pierced with holes, usually two for each cloth, punched through the canvas and protected by a small grommet stitched down close around them. These holes and those along the head for securing the sail to the yard are placed alternately in the seams and the middle of the cloths, those in the seams being slightly lower than those in the middle, so that they take more of the weight.

For hooking the bunt whip to haul up the bunt in furling, two holes are worked in the sail, one on each side of the midship seam about eighteen inches below the head, and through these are rove the parts of a short span having a thimble seized in the bight abaft the sail. This is a glut. Sometimes additional gluts are worked for furling with one or more reefs.

The holes in the reef-bands are fitted with reef-points, for holding the bands up to the yard when the sail is reefed. On the topsails, these points consist of pieces of small manila stuff, long enough to go around the yard and tie on top. They are rove through the holes in the reef-bands, one-third of the length being left forward and two-thirds abaft, and are stitched to the sail to prevent unreeving. The reef-points of courses are middled and stuck through from the after side of the sail so that both ends hang down forward. A rope jackstay is rove through the bights and stitched to them and to the sail.

In reefing, the points of a topsail are passed around the yard itself, those of a course only around the jackstay on top of the yard. Both are tied with "reef-knots."

The first and second reefs of topsails are often fitted with rope jackstays on the sail and beckets on the yard. The jackstay runs along the reef-band from hole to hole as in Plate **31**, forming a series of bights on the forward side of the sail, through which the becket is passed for reefing. This is called a "French reef."

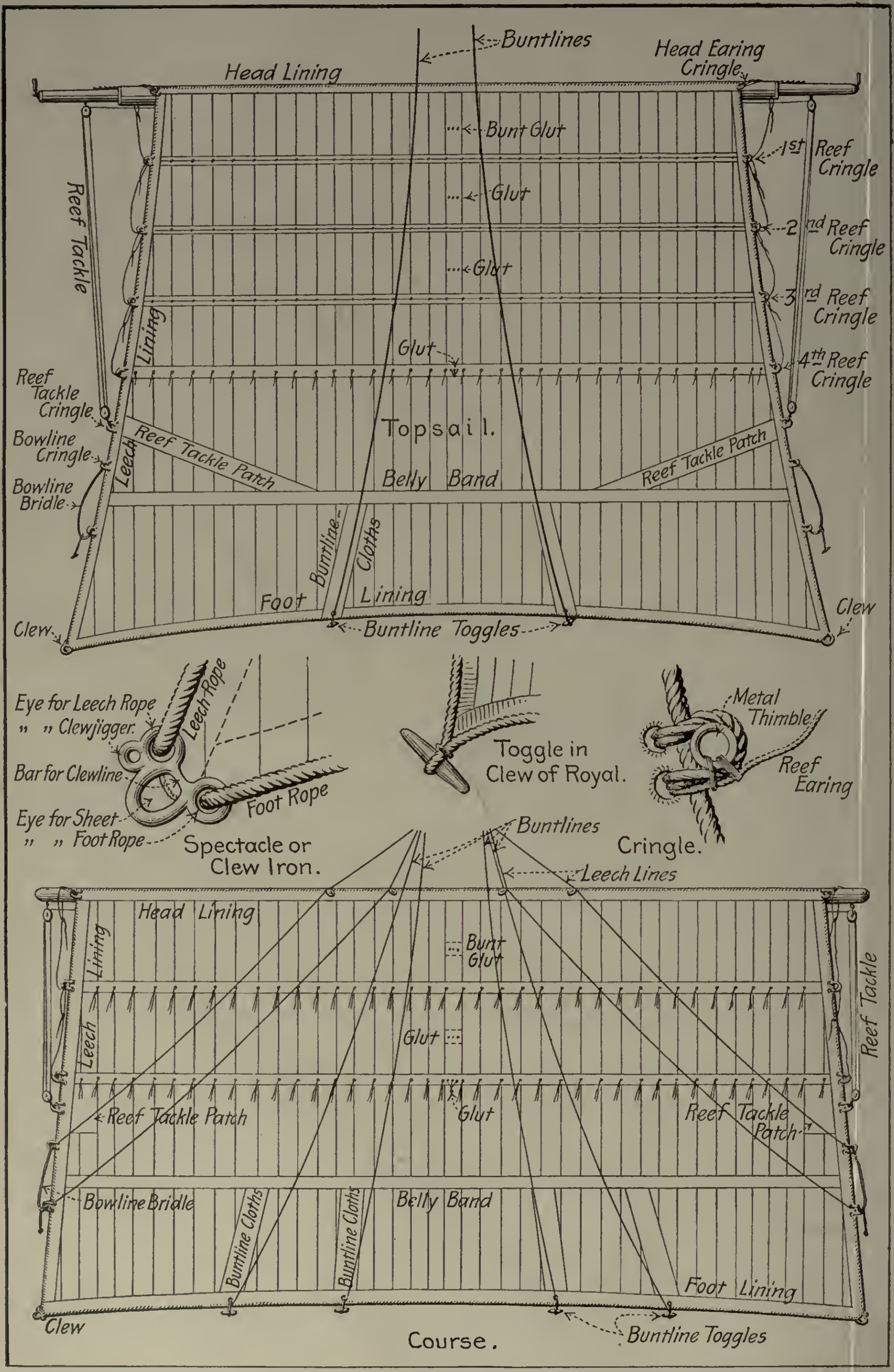
Reef-earings are of 2¼ to 2½-inch manila, spliced into the lower cringle-hole, seized to the lower side of the cringle, and secured with a bowline when not in use, to the cringle of the reef above, or to the head-earing cringle. They haul the cringle up and out on the yard in reefing, and hold it there. (See Chapter on Making and Taking in Sail.)

With French reefs, as above described, "bull-earings" are used. There are fixtures on the yard instead of on the sail.

Harbor gaskets, as used for neatness on men-of-war, are of sennit, long enough to go around the sail when furled, and are stitched to the head of the sail abaft, between the roping and the canvas. A tail in the end of the gasket is made fast to a staple on top of the yard.

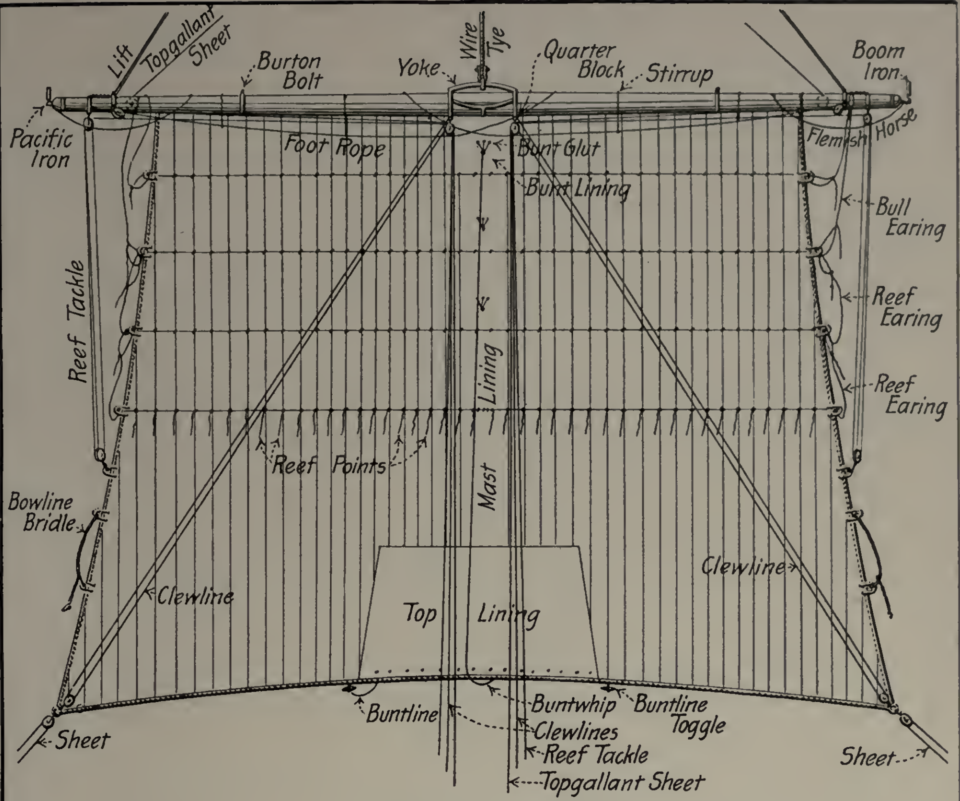
Storm sails are the sails used in lying to for riding out a gale. The sails commonly used for this are the close-reefed main topsail, the main trysail, the fore storm-staysail and the storm-mizzen or the mizzen

Plate No. 34.

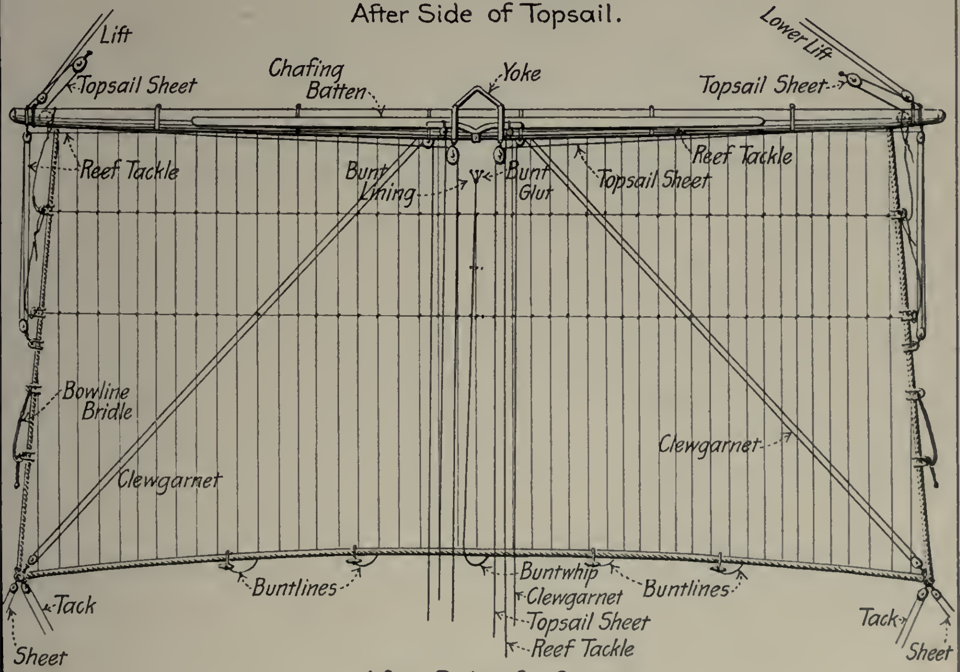


SQUARE SAILS, MAN-OF-WAR.
(FORWARD SIDE)

Plate No. 35.



After Side of Topsail.



After Side of a Course.

SQUARE SAILS, MAN-OF-WAR.

storm-staysail. Of these, only the three last-named are exclusively storm sails.

The fore storm-staysail sets on a special stay which toggles temporarily into the collar of the fore stay and sets up on the forecastle.

The storm-mizzen is a triangular sail which is set on the mizzen mast, its luff being secured by good stops around the mast. The mizzen storm-staysail sets on the mizzen stay.

Any or all of these sails may be used for lying-to in any given case, according to the build and trim of the ship, and the conditions of wind and sea.

Studding sails ("Stun sails") are sometimes set beyond the leeches of the foresail, fore topsail and fore and main topgallant sails in running free, being hauled out to booms which project beyond the yard-arms. They are more fully described in Chapter XXV.

Double Topsails and Topgallant Sails.—Modern sailing ships almost without exception have double topsail yards and in many cases double topgallant yards as well. This rig was first proposed by an American shipmaster named Howe, and its many advantages were promptly recognized (Plates **28** and **32**).

In this rig, the lower topsail yard is fixed, while the upper yard hoists and lowers, the sail having half the depth of a single topsail. The lower (topsail) yard is trussed to the main cap, and the upper yard, when lowered, lies close above it. Thus by lowering the upper topsail, sail is reduced in a moment to the area of an old-fashioned topsail when close-reefed, the upper topsail, when lowered, hanging forward of the lower topsail, where it is to a great extent becalmed.

Downhaul tackles are fitted from the yard-arms of the upper to those of the lower (topsail) yards to haul the yards down. This takes the place of "clewing-down" with a single topsail. The downhauls also support the lower topsail yard-arms, for which, usually, no lifts are fitted.

The lower topsail is fitted with sheets and clew-lines like an old-fashioned topsail, but as the leech is short, the clew-line blocks are placed well out on the yard. As a rule, the clews of the upper topsail shackle permanently to the lower topsail yard-arms.

In furling the upper topsail the sail is gathered directly up to the yard as in reefing;—that is to say, it is not passed in to form a bunt at the slings of the yard. The buntlines assist in gathering the sail up, being rove as shown in Plate **32**.

Sea-gaskets are always used and are passed from the yard-arms in. As the clews remain shackled to the yard below, a few turns of the gasket are taken around them between the two yards.

As the foot of the upper topsail does not span a stay, it is cut with only a slight roach. In the first ships fitted with this rig it was cut perfectly straight, and laced to the yard below it.

Although the general practice is, as above stated, to leave the clews of the upper topsails permanently shackled to the lower topsail yard-arms, many officers like to use sheets for hauling out the clews of these as of other sails. This admits of easing away a little in reefing and furling, and, in general, gives better control of the sail. It does not, however, change the principle upon which the sail is handled, since the sheet is not accompanied by a clew-line, and *the sail is never clewed up.*

The upper topsail usually has one reef and sometimes two, fitted as in the case of other topsails.

The details of rigging and fitting double topsails are shown in Plates **28** and **32**.

§ II. RUNNING GEAR.

The ropes, purchases, &c., by which the yards and sails are controlled constitute the Running Gear of the ship. Most of this gear is shown so clearly on Plates **28**, **31**, **32**, **33**, **34** and **35** that a detailed description of their lead is unnecessary.

Halliards.—Yards are hoisted by purchases consisting usually of a pendant, called a tye and a purchase called the halliards. The topsail tye is of flexible wire, reeving through the gin-block at the masthead, down through the tye-block on the yard and up to the topmast head, where the standing part is secured, usually by hitching it around the masthead. The halliards consist of a two-fold purchase, the upper block hooking to a thimble in the after end of the tye and the lower block in the chains or on deck. In large ships, two tyes and halliards are used, one on each side, rove as above, the two tye blocks on the yard being separated by the diameter of the mast. In smaller ships, having only a single tye and halliard, a large single block (called a fly-block) is hooked to the after end of the tye, and through this is rove a runner, having the upper block of the halliards hooked to one end while the other end makes fast to the ship's rail or to the deck.

The topgallant tye reeves through a sheave in the mast and hooks to a band on the slings of the yard. The upper halliard-block hooks to a thimble turned in the after end of the tye in such a way that it can be easily turned out for unreeving the tye. The lower block of the halliards hooks in the top and the fall is led on deck.

The royal tye and halliards are rove like the topgallant.

On men-of-war, where topgallant and royal yards and topgallant masts are sent up and down frequently, long yard-ropes are used in addition to the tyes, the tyes being unbent for sending down the yards, and unrove for sending down the masts. To avoid the necessity of unreeving the long yard-ropes also (for sending down the masts) they are rove through "jack-blocks" hooked to straps on links under the eyes of the rigging.

The halliards of a staysail are bent to the head of the sail, lead up along the stay to a block at the masthead and thence on deck. For heavy sails, the halliards are double, and reeve through the blocks at the head of the sail, the standing part being made fast aloft and the hauling part leading as before.

The gaffs of trysails are supported by spans from the lower mast to the throat and peak, and when necessary may be hoisted and lowered by throat and peak halliards (Plate **33**).

Studding-sail halliards are bent to their yards, rove through jewel-blocks at the ends of the yard-arm or booms, through blocks hooking to long straps at the masthead and thence to the deck. For the inner halliards of a lower studding sail, a clew-jigger is used, one block hooking at the cap, the other at the inner head cringle. There is a difference of practice as to leading studding-sail halliards forward or abaft the yard-arms, but experience proves that there is less chafe if they are led forward.

Braces.—Yards are controlled as to their horizontal movement by braces leading from the yard-arms aft or forward. They are always led aft if circumstances permit this without requiring too much of a downward lead. In three-masted ships, the braces of yards on the fore and main are led aft, those of yards on the mizzen, forward.

The manner of reeving braces on modern ships is shown in Plates **28** and **32**.

Method of reeving braces in old-fashioned sailing ships:

The standing part of the fore brace hooks to a bolt at the main bibbs, leads through a block on the yard-arm, back through a block at the bibbs and so to the deck. The fore topsail brace leads from the main topmast head through a block on the yard, down to a block on the main stay (to clear the foot of the topsail), through a block at the main bibbs, and then to the deck. The fore topgallant brace hooks to the lift and brace band on the yard-arm, reeves through a block on the collar of the main topmast stay, then through another block under the eyes of the main topmast rigging and so to the deck. In large ships, a whip is hooked to the end of this part and led on deck. The fore royal brace hooks to a band on the yard-arm, leads through a block under the eyes of the main topgallant rigging and thence on deck.

The standing part of the main brace hooks to a bumpkin projecting from the quarter, reeves through the block on the yard, back through a block on the bumpkin, and through a sheave in the rail, and belays at the mizzen-pin rail. The standing part of the main topsail brace hooks to a band which travels up and down the mizzen topmast, reeves through the block on the yard, then down to a block on the mizzenmast between the top and the deck.

The main topgallant and royal braces reeve like the fore, substituting "mizzen" for "main."

The crossjack, mizzen topsail and mizzen topgallant and royal braces lead forward to the main mast, very much as the other braces lead aft.

The boom-brace of the topmast studding sail goes over the end of the boom with a running eye, reeves through a block tailed on to the forward swifter of the main rigging, and belays to the main pin rail.

Lifts.—Yards are supported at the yard-arms by lifts, leading through blocks or fair-leaders at the masthead and thence to the top or the deck. Lower lifts are double, the standing part hooking to the strap of a block at the lower cap, reeving through a single block at the yard-arm, back through the block at the cap, and then on deck. The lifts of single topsail yards are single, hooking to a bolt at the yard-arm and leading through a fair-leader between the forward swifters of the topmast rigging to the deck. The lifts of upper topsail yards are double and rove through a block at the masthead, one end hooking to the yard-arm, the other to the quarter of the yard.

Lower topsail yards usually have no lifts, being supported at the yard-arms by hauling taut the downhaul tackles of the upper yards.

Topgallant and royal lifts are single, hooking to the same yard-arm bands as the braces, and leading through fair-leaders between the shrouds and thence to the top.

Sheets.—The clews of square sails are hauled out to the yards below them by sheets, reeving through sheaves in the yard-arms, thence through quarter-blocks under the yard and so to the deck. Topsail sheets are usually of chain, rove as above but with a whip from deck hooking to the chain below the quarter-block. The fittings for the clews of upper topsails have been described in the preceding section. Topgallant and royal sheets are single.

In old-fashioned men-of-war the topsail sheets are rove as follows: The standing part hooks to the yard-arm, reeves through a block at the clew of the sail, through the sheave in the yard-arm, through the quarter-block, thence on deck.

Staysail and trysail sheets consist of pendants and whips, and are usually double, each sail having its port and starboard sheet. In the case of a sail hauling out to a boom, the purchase for controlling the boom is the "sheet" and the sail is hauled out by an "outhaul."

Tacks.—To control the clews of the courses, not only sheets, but tacks, are needed, the tack hauling the weather clew down and forward, the sheet hauling the lee clew down and aft.

Midship tack.—A "midship tack" is often fitted, as in Plate **32**. This makes fast to a bolt on one side of the deck, reeves through a bull's-eye on the foot of the sail and belays to a cleat on the other side of the deck. By keeping this fast and hauling the clews up forward of the yard, a triangular reef is put in without the necessity of sending a man aloft.

Clew-lines.—In taking in the sails, the clews are hauled up to the quarters of the yard by clew-lines leading from the clews to the quarter-blocks and down on deck. For topsails and courses the clew-lines are double, and reeve through a block at the clew, the standing part being clinched around the quarters of the yard.

The clew-lines of courses are called clew-garnets.

Secret blocks are used at the clews of topsails and courses to avoid danger of fouling reef points.

Owing to the limited "drop" of a lower topsail as compared with its spread, the clew-line blocks are well out on the yard, and the sail—instead of being furled like a course, with a full bunt and lean yard-arms, is to a great extent rolled up;—indeed it is sometimes clewed up directly to the yard-arm, the clew-line block being placed outside the head-earing. This, however, is not usual.

Clew-lines or clew-ropes are fitted to trysails for hauling the clew up to the jaws of the gaff, and on gaff topsails for hauling the clew up to the head.

A clew-line is used with a square lower studding sail to haul the clew up to the inner yard-arm.

Leech-lines are used to haul the leeches of courses and sometimes of topsails along the yard. They reeve through blocks at the masthead or the tcp-rim, then through blocks on top of the yard, and make fast to the leech at a distance from the head-earing cringle equal to the distance from the same cringle to the block on the yard.

Buntlines.—Buntlines haul the foot of the sail above and forward of the yard for convenience in furling. They are rove through blocks at the masthead or the top rim, lead down forward and toggle to the foot of the sail some distance outside the midship line on each side. The buntlines of an upper topsail or topgallant sail lead through blocks some distance out on the yard (as in the case of leech-lines), and instead of toggling to the foot-rope, are rove through thimbles there and brought up abaft the sail, where they are made fast around the yard close to their respective blocks. There are usually two of these on each side, and one amidships. They thus act like brails, gathering up the foot and body of the sail and binding it to the yard.

Bunt-whips.—Bunt-whips or bunt-jiggers hook to the bunt-gluts on the after side of the sail a little below the head, to haul the bunt up in furling.

Reef-tackles.—Reef-tackles are whips leading from the yard-arms of topsails and courses to cringle on the leeches of the sails, for hauling the leech up and out in reefing, affording slack for passing the earing and rousing the cringle up to its place.

Bowlines.—Bowlines lead forward from the bowline bridles on the leeches of courses and topsails, and are used, when sailing on the wind, for hauling the leech well forward so that it shall hold the wind.

Outhauls.—The head of a trysail is hauled out by a head outhaul, reeving through a sheave in the end of the gaff and a block at the mast, and then to the deck. The foot of a boom-sail is hauled out by a foot-outhaul reeving through a sheave in the boom. (For lower studding sail outhaul, see **Tacks.**)

Downhauls.—Staysails are hauled down by downhauls leading from the head of the sail along the stay to a block at the tack of the sail.

The head of a trysail is hauled down by a head downhaul from the head of the sail to the jaws of the gaff. Upper topsail and upper topgallant yards are hauled down by downhauls leading from their yard-arms to those of the yards below. These are rendered necessary by the absence of clew-lines. When the yards are lowered, the downhauls are kept taut and serve to support the lower topsail and topgallant yards, which have no lifts.

Topgallant studding-sail downhaul is bent to the inner yard-arm and leads abaft the topsail yard through the lubber's-hole to the deck.

The topmast studding-sail downhaul is bent to the *outer* yard-arm, reeves through a thimble seized to the outer leech of the sail midway of its length, through a block at the tack of the sail, and down, forward of the boom to the forecastle.

Brails.—Gaff sails—trysails, spankers, &c.—are gathered in to the mast for furling, by brails middled and stopped to the after leech, with a hauling part on each side reeving through a block on the mast at a point corresponding to the point at which they are stopped to the leech.

Vangs.—Vangs are fitted to gaffs at the after end—one on each side—and led to the ship's side. Their office is to steady the gaff *when the sail is not set.*

The details of the lead of running gear aloft are subject to change and are not of great importance. The details of their lead to the deck and especially of the points at which they belay, are of the greatest possible importance, and should be as nearly uniform and invariable as they can be made. *It should be possible for any seaman on a strange ship to go at once to any piece of running gear on the darkest night.*

CHAPTER V.

MECHANICAL APPLIANCES ON SHIP-BOARD.

The successful use of mechanical appliances on ship-board calls for a familiarity with certain elementary principles of mechanics which may thus be properly regarded as a part of Seamanship.

From this point of view they will be treated here as preliminary to the handling of heavy weights.

The popular conception of forces and of the manner of measuring them may be accepted as sufficiently exact for our present purpose.

THE COMPOSITION AND RESOLUTION OF FORCES.

For every force acting upon a body there is a certain "line of action" along which it tends to move this body. If several forces act upon the same body at the same time, the total effect produced will be, both in magnitude and in direction, a combination of the effects of the individual forces; and it is found that we may substitute for any such combination of forces, a single force of definite magnitude and direction; and that the magnitude and direction of this "resultant force" as it is called, may be deduced from the original forces by a very simple construction.

The derivation of a single resultant from several distinct forces is called "The Composition of Forces."

It is found also that we may reverse the above process, and, from a single given force, find two or more forces acting along given lines which may be substituted for the one original force without any change in the effect produced. This process is called "The Resolution of Forces"; and the forces resulting from it are "components" of the original force from which they are derived. In discussing these principles and applying them to practical problems, we may conveniently denote a force by a line of a certain length, the number of units of length taken being equal to the number of units of force to be repre-

Plate No. 36.

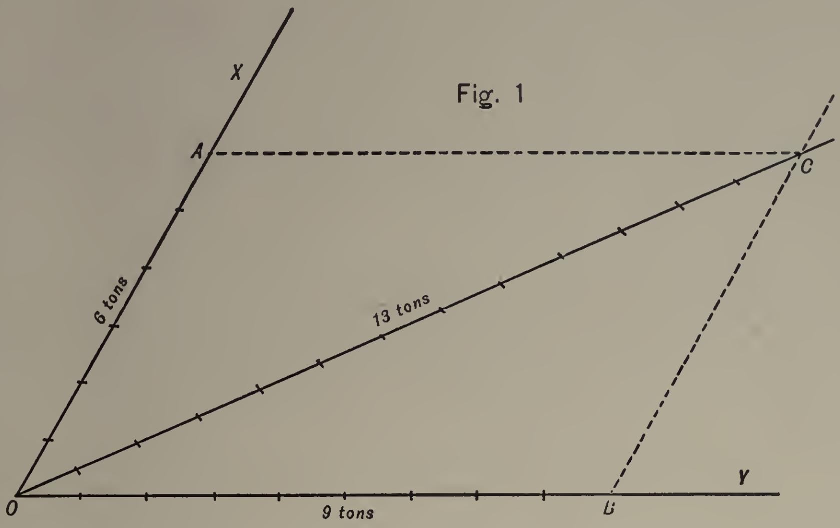


Fig. 1

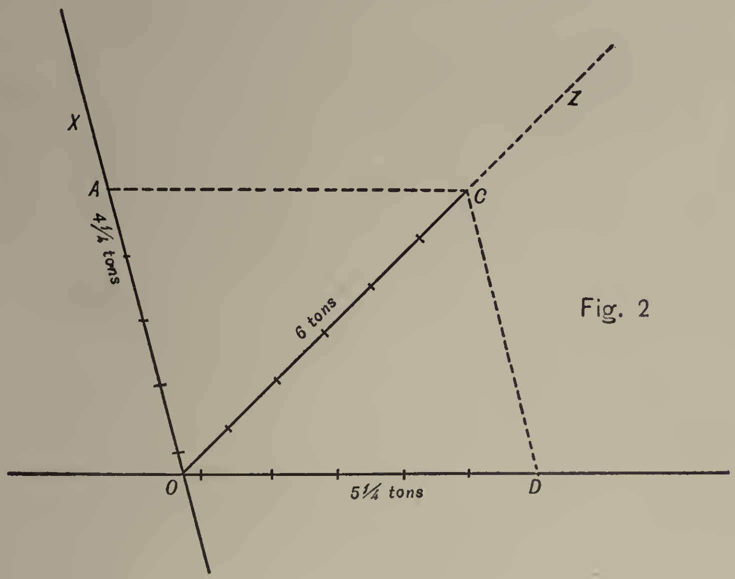


Fig. 2

THE COMPOSITION AND RESOLUTION OF FORCES.

sented. Thus a force of 5 tons may be denoted by a line five units in length;—the units being feet, inches, tenths of inches, or anything else that we like to use. The scale is merely a matter of convenience, but the same scale must of course be used in all parts of the same problem.

We proceed to illustrate the Resolution and Composition of Forces.

In Fig. 1, Plate **36**, suppose O A and O B to represent two forces acting along the lines O X and O Y, and suppose it is desired to find a single force which may replace these without change in effect upon O. We construct the parallelogram A O B C and draw the diagonal O C. This diagonal represents, in direction and in length, the desired resultant; its length being measured, of course, in the same units that have been used in laying off O A and O B. In this case, if O A = 6 tons and O B = 9 tons, O C, the resultant = 13 tons. That is to say, a force of ten tons acting along O Z, will produce exactly the same effect as six tons acting along O X and nine tons acting along O Y. If we have to deal with three or more original forces, we may couple two of them and find a resultant, then couple this resultant with another one of the original forces and proceed as before to find the resultant of these, and so on.

It is clear that, by reversing the above process, we may resolve a single given force into two or more others acting along certain lines. Having given 13 tons acting along O Z, suppose we are called upon to find two forces which, acting along O X and O Y, shall be equivalent to this original force. As before, we construct the parallelogram A O B C. Then the sides O A and O B represent by their lengths the forces which, acting in these two directions, are equivalent to O C. O A is found to be 6 tons and O B, 9 tons. Similarly in Fig. 2, suppose we have a force denoted by the length of O C acting along O Z, and wish to resolve this along the lines O X and O Y, making angles of 45° and 60° with O Z. Constructing the parallelogram O B C A as before, we have the lengths O A = 4¼ tons, and O B = 5¼ tons, for the forces required.

Evidently, if a point is at rest, the forces acting upon it must balance each other. Consider the case illustrated in Fig. 1, Plate **37**, of a weight suspended from a boom, the heel of which is attached to the mast while the other end is supported by a topping-lift from the masthead. The forces acting here are the downward pull of the weight, the tension on the lift, and the resistance of the boom to compression (Fig. 2, Plate **37**). As the point O remains at rest, these forces must balance each other;—that is to say, each force considered by itself must be balanced in magnitude and direction by the resultant of the other two forces. If this were not so, motion would result. Suppose we wish to find the tension on the topping-lift. We lay off O C on any convenient scale to represent the downward pull of the weight, and on O C as a diagonal, construct the parallelogram O B C A (Fig. 1, a). O A is the measure of the tension on the topping-lift, and O B that of the thrust along the boom. If the weight is 9 tons, O A is 6¾ tons and O B is 4½ tons.

There follows from the above a simple and convenient rule for determining the relative stresses on the various parts of the system from a simple comparison of their relative lengths. The sides of the triangle O A C are parallel to the sides of the triangle formed by the mast, the boom, and the topping-lift.

These two are therefore "similar" triangles in the geometrical sense of the term, and it follows that the same relations exist between the sides of one of them as between the corresponding sides of the other; that is to say, the side O A, which represents the tension on the topping-lift, is the same proportion of O C, the downward pull of W, that the length of the topping-lift is of the length of the mast. From which we have the convenient rule expressed by the following proportion.

$$\frac{\text{Tension on Topping-lift}}{\text{Weight}} = \frac{\text{Length of Topping-lift}}{\text{Length of Mast}}$$

If the boom is stepped at a distance from the mast, this rule may be applied by prolonging the line of the boom until it intersects the mast, and using in calculation, the lengths given by this construction (Fig. 5, Plate **37**).

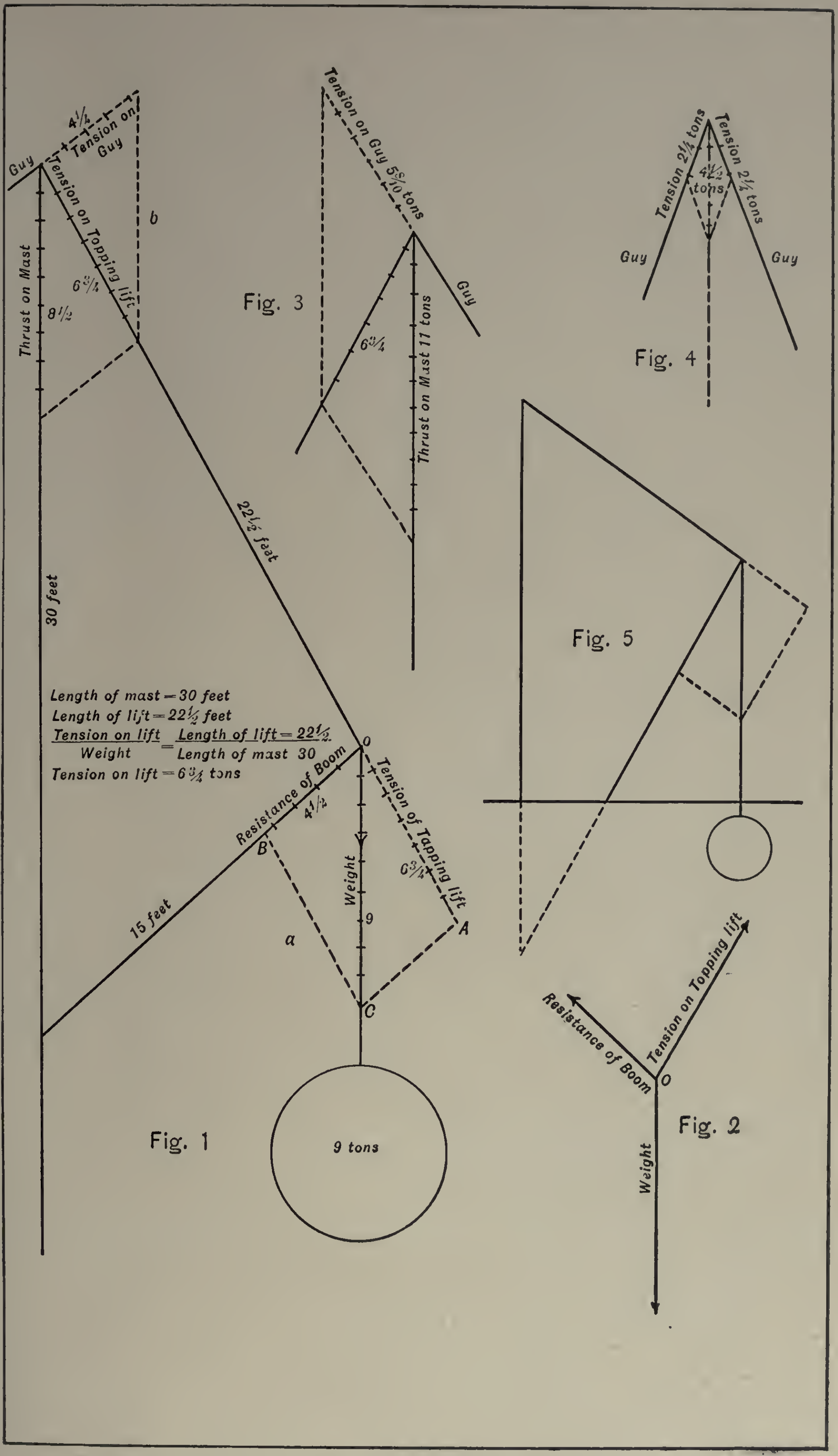
Similarly we may deduce the rule:

$$\frac{\text{Thrust on boom}}{\text{Weight}} = \frac{\text{Length of boom}}{\text{Length of mast}}$$

It will be understood that the lengths given above for mast and boom are those actually included in the triangles of Figs. 1 and 5.

This leads to a further important deduction with regard to the most favorable relation between the mast, the boom, and the topping-lift, as follows:

Plate No. 37.



THE COMPOSITION AND RESOLUTION OF FORCES APPLIED TO A DERRICK.

For a fixed length of mast and boom, we cannot change the thrust on the boom by any change in its angle; but we may vary the tension on the topping-lift within wide limits. Since this tension depends upon the length of the topping-lift, it grows less and less as the boom is topped up, becoming a minimum when the boom is as nearly vertical as it can be made. It is, at this point, very much less than the tension on O W due to the direct downward pull of the weight; but if we lower the boom toward the horizontal we presently reach an angle, depending upon the length of the boom, at which the length of the lift is equal to the length of the mast. At this point, then, the tension on the lift is equal to that along O W. If we lower still further, the tension on the lift increases beyond that on O W and may become very much in excess of it. For a given length of mast and boom, then, the more nearly vertical the boom can be used the better. If we are at liberty to vary the length of the mast and boom to attain *a given reach,* we shall find that a short boom, nearly level, gives a minimum strain on the boom and a maximum strain on the lift; while a long boom, well topped-up, gives a maximum strain on the boom and a minimum strain on the lift.

Suppose the boom is half as long as the mast. The thrust on it will be one-half the weight, no matter what the angle of the boom may be. The tension on the topping-lift will be about 1¼ times the weight when the boom is level, and rather less than ¾ of the weight when the boom is topped up to 45°.

The practical conclusion from this is that if we are called upon to rig a derrick we should consider carefully the relative trustworthiness of the materials with which we have to work. If we have a topping-lift which is abundantly strong, to be used with a boom about which we are not so sure, it is well to make the boom as short as possible and keep it nearly level. If on the other hand the boom and its fastenings are known to be safe but the topping-lift is not entirely satisfactory, we should use the full length of the boom (or choose a longer one if we have a choice) and top it up as far as possible, to give the required reach. If the reach is such that a *long boom must be used and kept nearly level,* we have the maximum of unfavorable conditions as regards both boom and lift. In this case all that we can do is to lead the lift from a point as far up the mast as is practicable. This increases the absolute length of the lift, but decreases its relative length as compared with the mast; and, as we have seen, it is the relative and not the absolute length that determines the proportion of strain to be borne by the lift.

This case—of a long boom nearly level—is the ordinary one of a lower yard used for handling weights.

If the weight is suspended from the boom (or yard) outside or inside of the point at which the lift or burton is made fast, the situation is somewhat modified, as will be explained in connection with the Lever.

If we wish to find the tension on the guys or shrouds supporting the mast, we start with the tension on the lift, and resolve this along the lines of the guy and the mast, exactly as we have already resolved the downward pull of the weight along the line of the boom and the lift. In Fig. 1, b, Plate **37**, the tension on the guys is found by this method. In the particular case there illustrated it proves to be 4¼ tons. If we vary the lead of the guy, we shall find that, by bringing it closer to the mast, as in Fig. 3, we increase the tension on it, exactly as we do in the case of the topping-lift when we bring this down the mast and make it fast only a little distance above the heel of the boom.

If there are two guys (or shrouds) in use, we have only to resolve the tension above found for a single guy along the lines of the two which replace it, as in Fig. 4. In this particular case, assuming the angle between the guys to be 40°, we find the tension on each to be 2¼ tons.

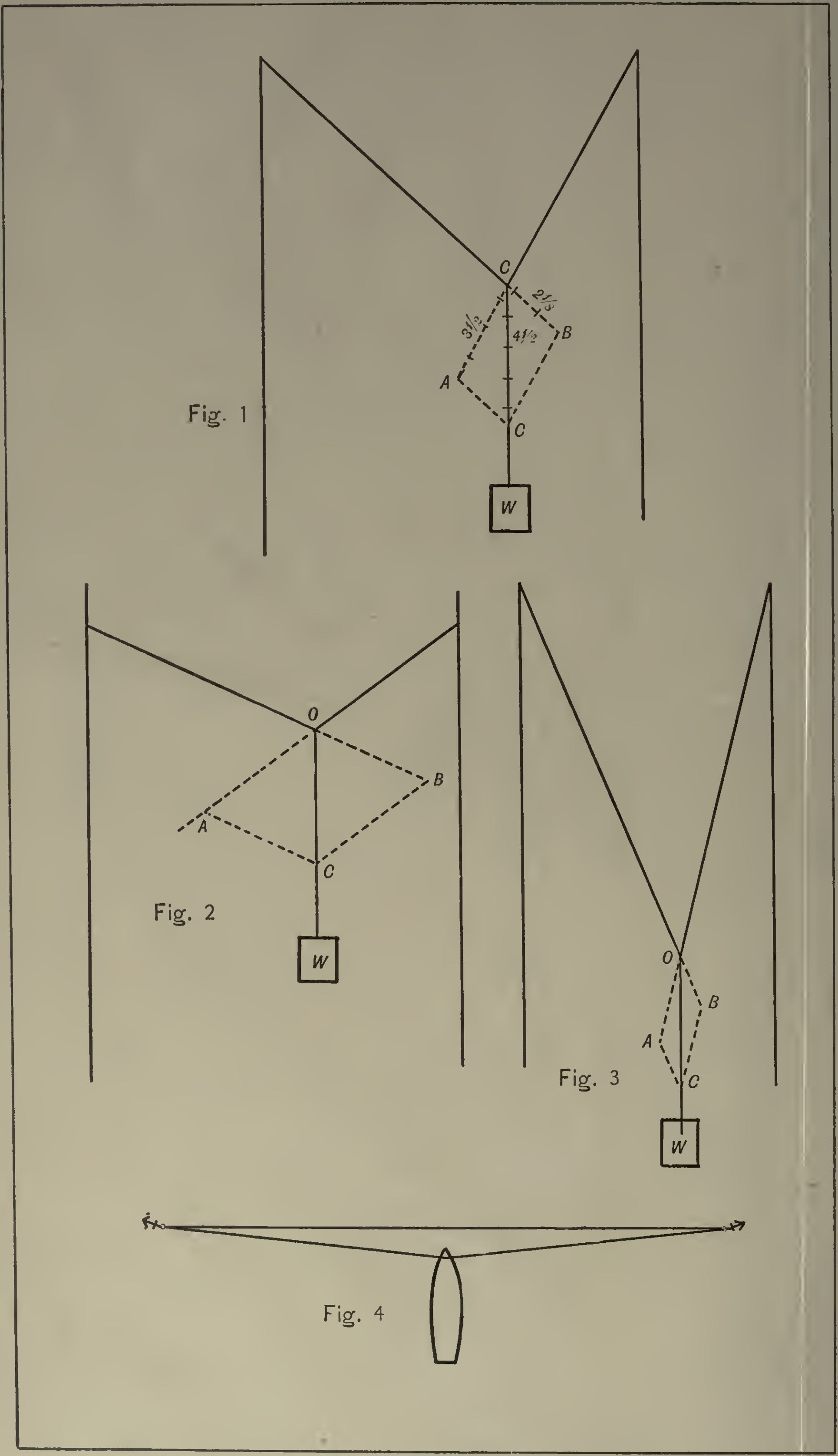
There is an important difference between the case in which the derrick is used with a fixed elevation and that in which it is to be topped up or lowered with the weight hanging from it. In the first case, the only demand upon the parts of the topping-lift is that arising from the downward pull of the weight, this pull being resolved along the line of the topping-lift as above described. In the second case, there is added to this an important percentage due to the resistance of friction, as is explained in the Chapter on Tackles.

(See Practical Examples at the end of Chapters VI and VII.)

The Span.

As another practical example of the resolution and composition of forces, we may consider the Span (Plate **38**).

Plate No. 38.



THE COMPOSITION AND RESOLUTION OF FORCES.
APPLIED TO A SPAN.

Suppose first that this is rigged between two masts for plumbing a hatch. If the two parts of the span make equal angles with the vertical, they will bear equal strains; otherwise the one which hangs more nearly vertical takes the greater strain. In Fig. 1, if the length O C represents the number of units of force in the downward pull of W, we find the tension on the two parts of the span by constructing the parallelogram of forces as in the cases already considered; O A giving the tension on one part and O B that on the other. It will be noted that if the parts of the span are opened out, increasing the angle A O B, as in Fig. 2, the parallelogram is flattened out, with a rapid increase in the length of the sides which represent tensions on the parts; whereas if they are brought together, as in Fig. 3, the tensions indicated on the parts are reduced. When the angle of the span is 120°, the tension on each part is equal to the direct downward pull of the weight; or, in other words, the span is just equal in strength to the single part O W. If the angle is reduced below 120°, the tension on each part decreases, until, when they are parallel, they divide between them the total tension due to the weight;—in other words, the two parts are now twice as strong as the single part O W. On the other hand, as the parts open out beyond 120°, the essential weakness of the span becomes more and more apparent, the tension on the parts increasing enormously as the angle between them approaches 180°.

It is evident from the above that the use of a span is objectionable unless the angle between the parts can be made small; and that in any case where it is to be used, the higher up the masts the parts can be made fast, the better.

A familiar example of a span is furnished by the cables of a vessel moored and riding with an open hawse. If in Fig. 4, Plate **38**, the parts of the span represent the cables of such a vessel, making an angle of 170° with each other, it can be shown that for a force of 10 tons acting along the keel line, we have a tension of 57.3 tons on each cable. In other words, two cables used in this way are only about one-sixth part as strong as one cable laid out ahead. (See Chapter on Ground Tackle.)

THE LEVER.

Another important principle of Mechanics which is involved in work on ship-board is that of the Lever.

A lever is a rigid bar movable about a fixed point called the "fulcrum."

It is a matter of every-day experience that two equal forces applied at equal distances from the fulcrum of a lever will balance; and that a small force applied at a considerable distance on one side will balance a greater force applied at a shorter distance on the other side. We have here illustrated, the principle of the lever; or, as it is sometimes called, the Principle of Moments; a "moment," in the mechanical sense, being the product of a force acting on a lever multiplied by the length of the arm with which it acts.

The Principle of Moments is expressed in the following statements.

1st. The tendency of a force to produce motion about an axis is measured not by the magnitude of the force alone, but by the product of the force into the distance of its line of action from the axis.

2nd. If any system remains at rest, the sum of the moments tending to turn it in any direction about any axis must be equal to the sum of the moments tending to turn it in the opposite direction about the same axis.

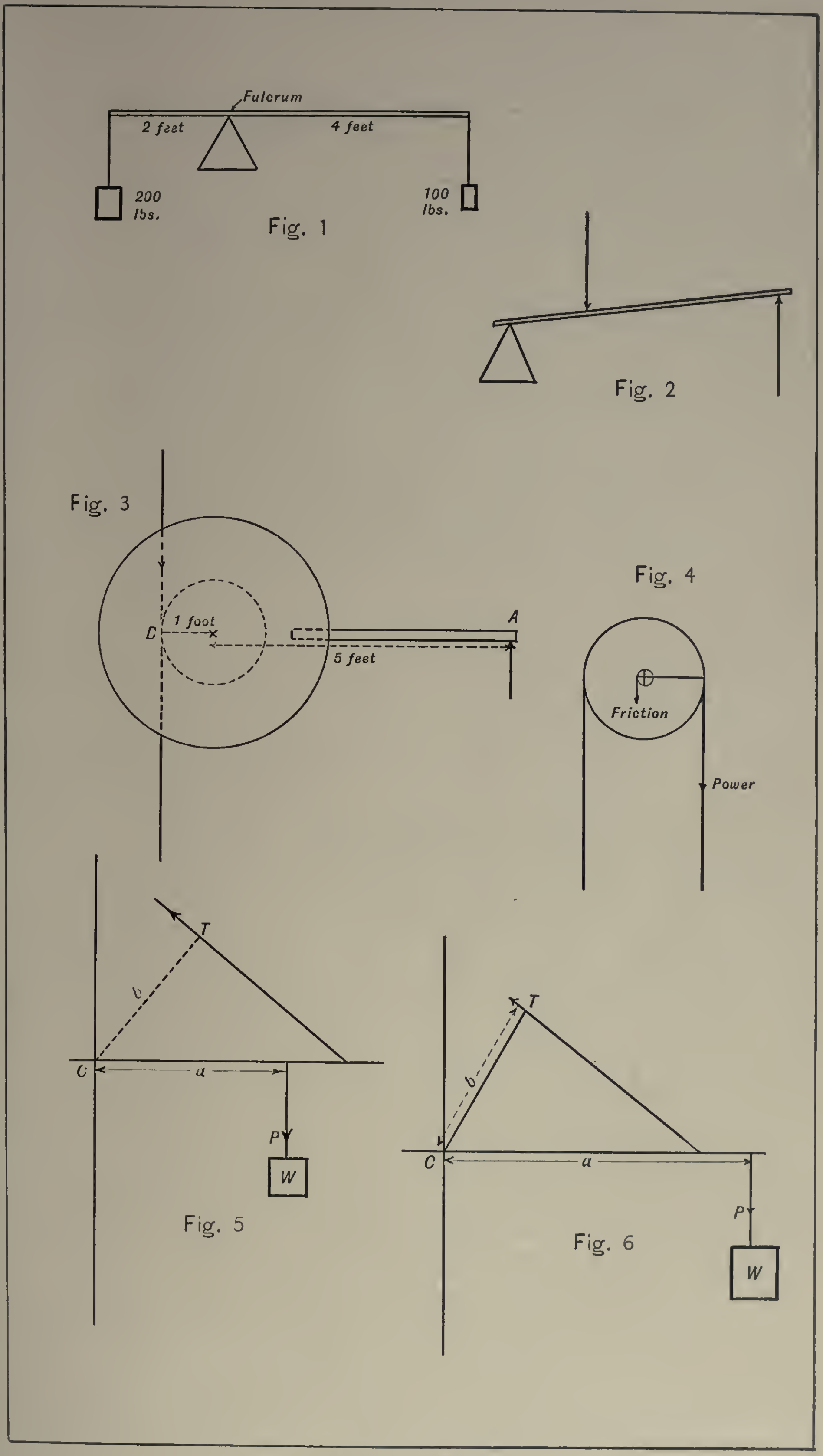
In Fig. 1, Plate **39**, the moments of the forces opposed to each other are respectively 4 × 100 foot-lbs. and 2 × 200 foot-lbs.; and as these balance, the system remains at rest.

It is by creating a difference between opposing moments that force is multiplied by means of a lever; a small force being applied with a long arm to overcome a large force acting with a short arm.

It should be noted that the forces whose moments are opposed to each other may act on opposite sides of the fulcrum, as in Fig. 1 or on the same side, as in Fig. 2.

Perhaps the most familiar example of a lever on ship-board is the old-fashioned capstan (Fig. 3), the principle of which is preserved in the winches and windlasses of modern steamers. Another example of the lever, though one not always thought of as such, is the sheave of a block turning upon a pin by the tension of a rope passing over its periphery (Fig. 4). Here the friction between the sheave and the pin constitutes a force opposing the tension of the rope, and we have two moments as indicated in the figure. This is (in part) the reason for the rule that sheaves should be as large as is conveniently practicable.

Plate No. 39.



THE LEVER

The principle of the lever is involved in all cases where a force is applied to a rigid body at a point other than the point of support; as for example, in the case of a weight suspended from a yard or a derrick at a point inside or outside the lift or burton. In Fig. 5 the weight is hung inside the lift and the downward pull is divided between the lift and the truss. To find the tension borne by each, we must apply the principle of moments. Considering the axis of the system as at C (the truss), we have for our equation of moments $aP = bT$, where a and b are the two arms, P the downward pull of the weight, and T the tension on the lift.

If the weight is suspended outside the lift, as in Fig. 6, the equation is, as before, $aP = bT$; and since in this case a is greater than before, while P and b are unchanged, it follows that T must be greater than before. That is to say, the farther out on the yard a weight is hung, the greater the resulting tension on the lift.

THE TACKLE.

There is no mechanical appliance of greater importance than the tackle, but as this is fully treated in the next Chapter, it will be omitted here.

It is important to note that in all mechanical appliances by which power is multiplied, the gain in power is purchased by a proportional sacrifice of speed. Thus in the capstan (Plate **39**), the power applied at A is multiplied five times at B, but B moves only one fifth as fast as A. So in a tackle, as will be explained hereafter. And so in all cases where power is multiplied.

In all cases where yards, derricks, tackles, etc., are used for handling weights, it must not be overlooked that the weights of the spars, blocks, ropes, etc., are to be reckoned with in our calculations; the weight of each of these constituting a downward force acting at its individual center of gravity.

CHAPTER VI.

BLOCKS AND TACKLES.

(Plates **40** and **41.**)

§ I. BLOCKS.

A "Block," in the nautical sense, consists of a frame of wood or metal within which are fitted one or more sheaves or pulleys over which a rope may be led for convenience in applying power. If the block is properly used, it multiplies the power as explained in connection with Tackles. (§ II.)

A "made" block is built up of several pieces of wood or iron riveted or bolted together. In a "mortised" block, the frame is made of a single piece of wood mortised out to receive the sheave.

Sheaves may be of metal or of lignum-vitæ. If of the latter they are boushed with metal.

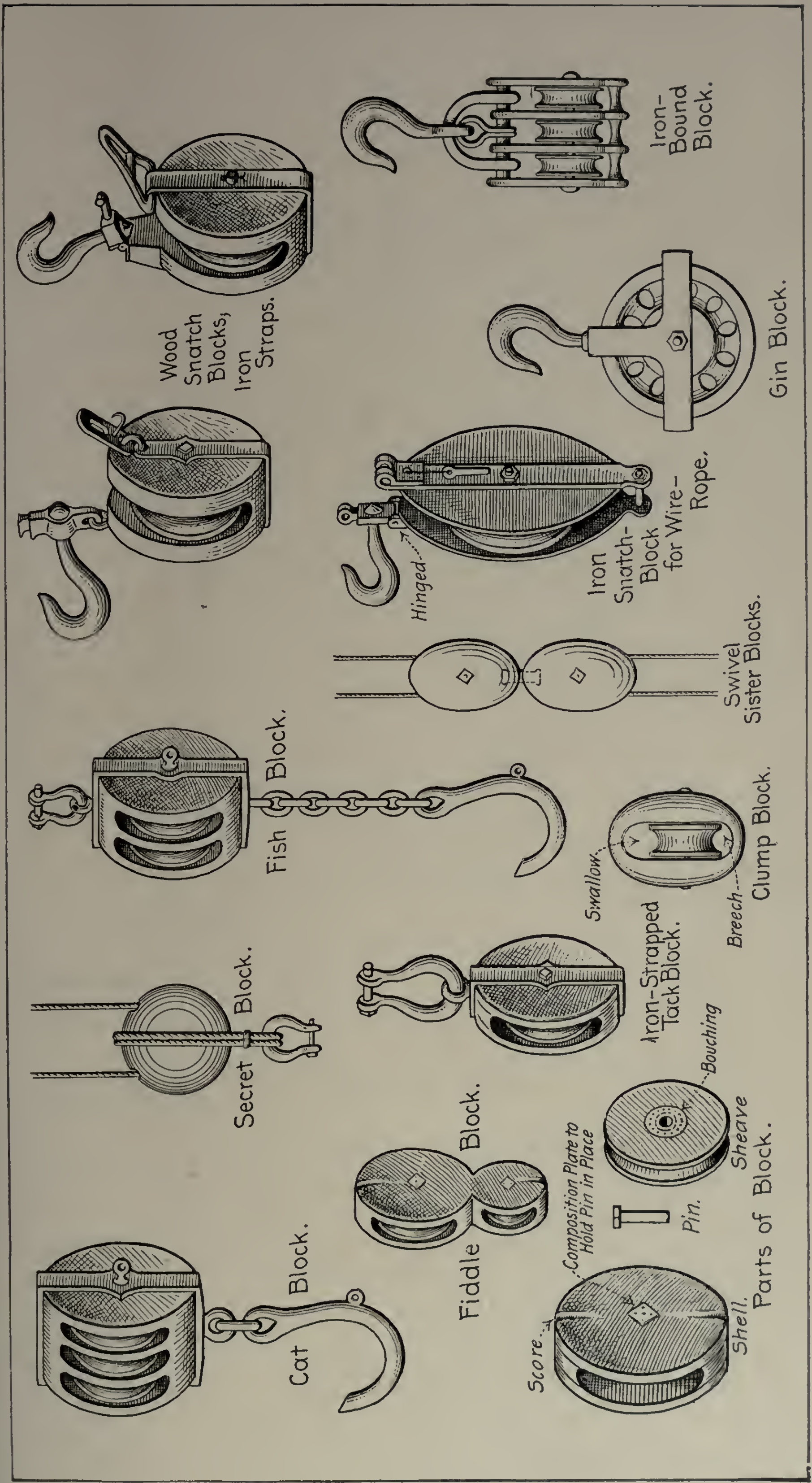
The swallow of the block is the space between the sheave and the frame, through which the rope passes. The side pieces of the frame are the cheeks, and the end of the block opposite the swallow is the breech.

A score is cut around the outside of the block to take the strap, which may be of hemp or wire-rope or of wrought iron. A hook or shackle is usually attached to the strap at one end of the block. The friction of a sheave upon the pin is an important factor in the efficiency of the block, as all power expended in overcoming this friction is wasted. For this reason blocks are often fitted with rollers or balls in the bearings for the pins. Such blocks, although in almost universal use, are commonly known as "patent-blocks."

The subject of friction will be treated at considerable length under the head of tackles, where it will be shown that a large sheave is essential for efficiency, and that the swallow should be large enough to prevent the rope from touching any part of the block except the sheave.

Special types of blocks are made for use with wire-rope.

Plate No. 40.



BLOCKS.

Blocks take their names from the purposes for which they are used, the places which they occupy, or from some peculiarity in their shape or construction. They are further designated as single, double, treble, and four-fold, according to the number of their sheaves.

Cat and Fish blocks are heavy double or treble blocks with large open hooks, used in catting and fishing an anchor.

Snatch-blocks are single iron-bound blocks, hooking to bolts on the deck to give a fair lead for boat-falls, topsail halliards, etc. The frame and strap are cut and hinged in such a way as to admit of "snatching" the fall on the bight.

Gin-blocks, or gins, are iron pulleys (single) of large diameter mounted in skeleton frames also of iron. Used chiefly for hoisting cargo, commonly with a wire-rope pendant.

Top-blocks are large single iron-strapped blocks hanging under the lower cap for the top-pendants used in sending up and down topmasts. The blocks at the topmast cap for the topgallant mast-rope are called topgallant top-blocks.

Jack-blocks are single iron-strapped blocks hooked under the eyes of the topgallant and royal rigging for the yard-ropes.

Quarter-blocks are single, double, or treble blocks hooked under the quarters of a yard, for sheets, clew-lines and sometimes reef-tackles.

Viol-blocks are very heavy single blocks, with a swallow large enough to take a small hawser.

Dasher-blocks are used at the ends of gaffs for signal halliards.

Tye-blocks are shackled to the slings of topsail yards for reeving the tye, in cases where this is double.

Fly-blocks are the upper blocks of topsail halliards, hooking to the thimble in the tye, abaft the mast.

Cheek-blocks are made with a half shell only, secured against the side of a spar.

Clump-blocks are short, thick, single blocks, with a large swallow, used for tacks and sheets, head-sheets, etc.

Secret-blocks have the sheave entirely enclosed except that holes are left on each side for reeving the rope. They are used for clew-lines and clew-garnets of topsails and courses to prevent the fouling of the block by reef-points.

Fiddle-blocks, shoe-blocks, sister-blocks, take their names from peculiarities of shape.

Strapping Blocks.—Rope is very little used on modern ships for strapping blocks, but wire-rope may sometimes be used with advantage, as being more reliable for a given calculated strength, than the iron work usually fitted. There is an especial advantage in this where very heavy weights are to be dealt with. For such work, a strap fitted with long lashing-eyes may be recommended.

As to the strength of blocks, see § IV of this chapter.

§ II. TACKLES.

A combination of ropes and blocks for the purpose of multiplying power constitutes a tackle.

If we reeve a rope through a fixed block and apply power at one end to lift a weight at the other, we have a "Single whip"; which is usually classed as a tackle, but gives no gain of power. If the block instead of being fixed is attached to the weight to be lifted, and one end of the rope made fast while power is applied to the other end, we have a tackle proper in its simplest form. Here (disregarding friction) the power applied to the hauling part is doubled at the movable block because it is transmitted around the sheave and so acts along both parts upon the mass to be moved. In the same way, the tension may be transmitted around any number of sheaves with a gain of power at each sheave of the movable block.

It should be noted that the tension is transmitted around the sheave of a fixed block exactly as it is around that of a movable one; but with no other effect in the case of the fixed block than to increase the pull upon the block and its supports. This point is often overlooked, but it is very important. If a weight of 100 lbs. is hanging from a yard-arm by a single whip *with both ends made fast to the weight*, the pull on the yard-arm is 100 lbs. If now we leave the weight hanging by one part of the whip and man the other part, or hold on to it, or make it fast on board, the pull on the yard is 200 lbs. The same point comes in with all purchases, but with less proportionate effect. If we have to find the tension on a yard or derrick to which a fixed block is made fast, we must add the tension on the hauling part to the direct downward pull of the weight.

Evidently, if we could neglect friction, we should have the simple rule that the power at the movable block is to the power

Plate No. 41.

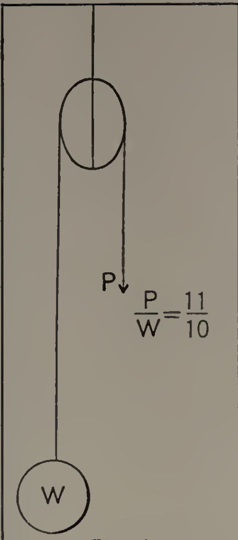


Fig. 1

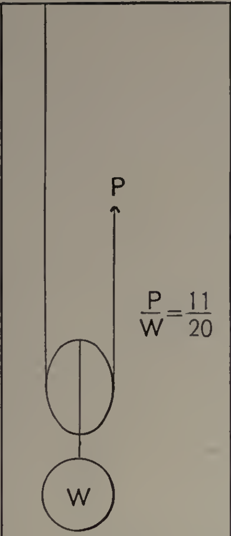


Fig. 2

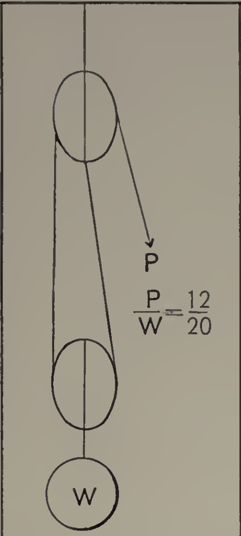


Fig. 3

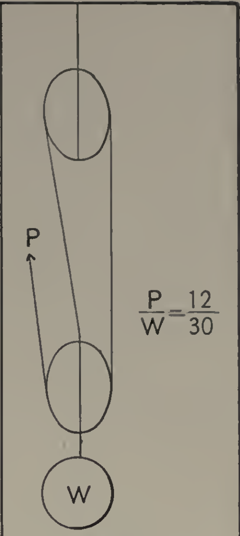


Fig. 4

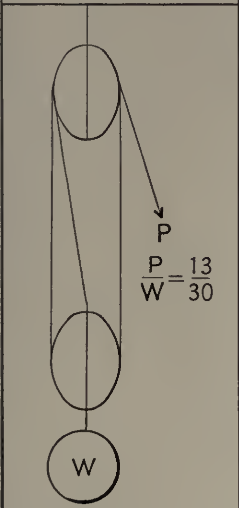


Fig. 5

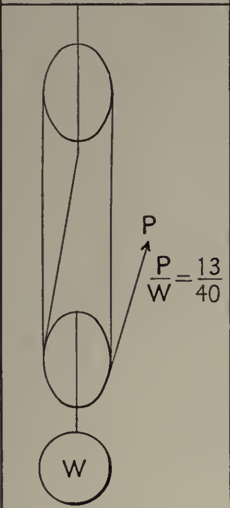


Fig. 6

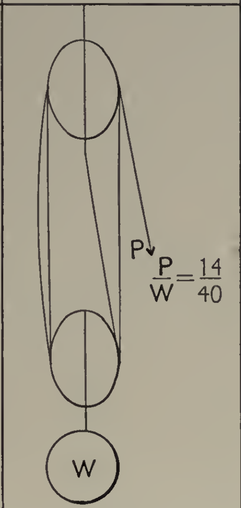


Fig. 7

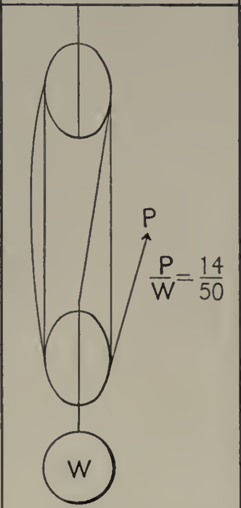


Fig. 8

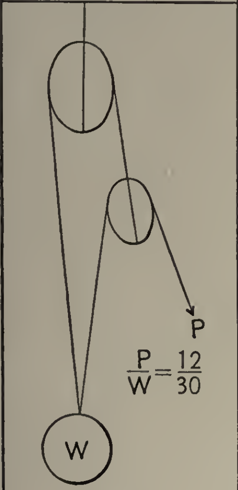


Fig. 9

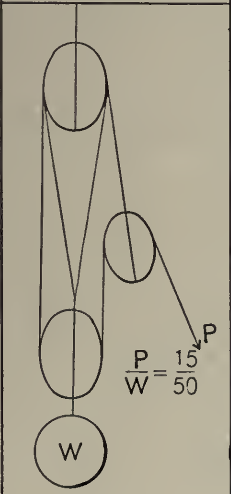


Fig. 10

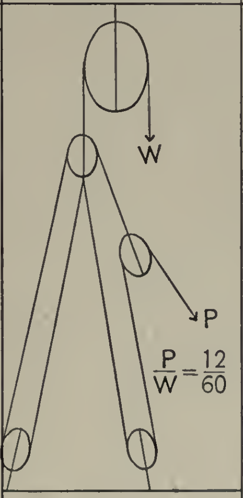


Fig. 11

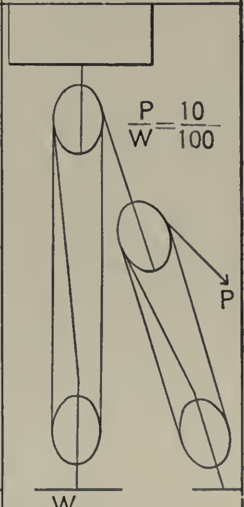


Fig. 12

TACKLES

Note:–
The ratios given for power to weight are based upon the allowance for friction described in Chapter VI.

Plate No. 42.

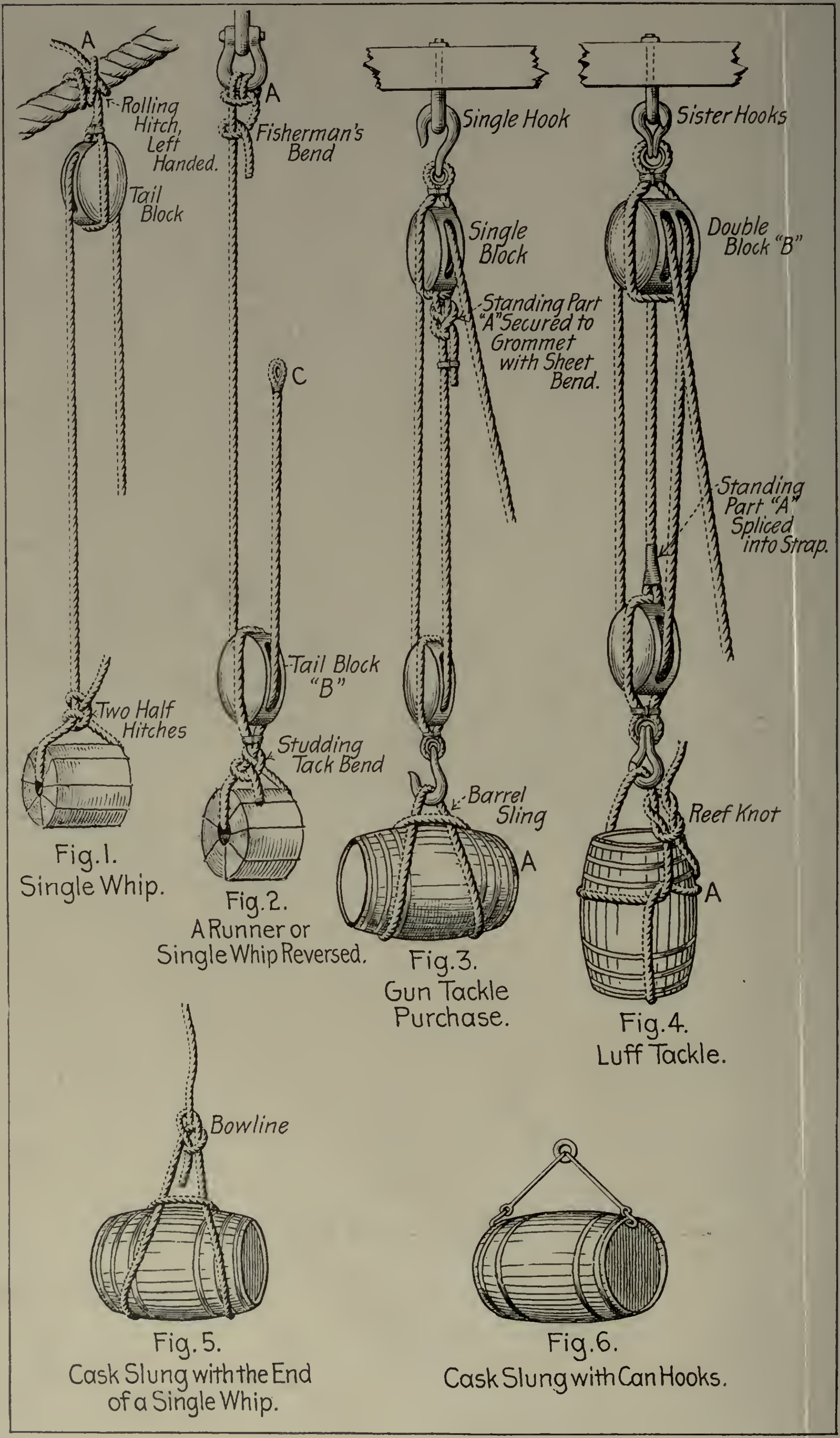


Fig. 1.
Single Whip.

Fig. 2.
A Runner or
Single Whip Reversed.

Fig. 3.
Gun Tackle
Purchase.

Fig. 4.
Luff Tackle.

Fig. 5.
Cask Slung with the End
of a Single Whip.

Fig. 6.
Cask Slung with Can Hooks.

TACKLES IN USE.

on the hauling part, as the number of parts at the movable block is to one; but in practice this rule is modified by the work absorbed each time the rope passes over a sheave. This work is accounted for principally by the friction of the sheave upon its pin; but the bending of the rope around the sheave with the accompanying deformation of the fibres counts for something, and in wire-rope may be an important part of the total loss. The stiffer the rope, the greater the loss from this source.

It results from this loss of power in passing around the sheaves that the tension on the successive parts of the fall grows less and less as we advance from the hauling toward the standing part and that the effective power of the tackle must be found by subtracting from the theoretical power, the proportion wastefully absorbed as above described. This proportion varies within wide limits; but it is always larger than is commonly supposed, increasing with the speed of working and with a decrease in the diameter of the sheave. It is reduced by low speed, and by the use of flexible rope and well-made patent blocks, having sheaves of large diameter as compared with the ropes they are to carry and kept in good order by frequent overhauling. If the rope touches the side of the block there is introduced a wholly unnecessary amount of friction with corresponding waste of power.

A small sheave, in addition to wasting power and increasing the wear upon the rope, introduces a direct and often fatal source of weakness by the difference in tension which it puts upon the successive layers of fibre from the inside to the outside of the bend, the outer layers being subjected to extreme tension while the inner ones are actually compressed. The result is that the outer layers give way and are followed by the others in succession toward the inside. This is the explanation also of the weakness in a sharp nip of any kind, whether due to a splice, a hitch, a bad lead or a bend around a pin or post.

Observe that whereas *in hoisting*, the maximum tension comes on the hauling part, *in lowering*, it comes on the standing part.

If the system is at rest, friction will tend to keep it at rest and will reduce the power needed at either end to maintain equilibrium. Thus if we have a mass of 800 lbs. hanging from the lower block of a two-fold purchase, we should require 200 lbs. on the hauling part to maintain equilibrium if there were no friction; but since in practice there is and must be friction, we shall be able to prevent motion by much less than 200 lbs. As an extreme case, we may imagine the friction so great that nothing is needed on the hauling part to prevent the lower block from moving;—the weight of 800 lbs., not being sufficient to "overhaul" the tackle. Similarly a mass of 200 lbs. on the hauling part may be held at rest by much less than 800 lbs. on the lower block, the friction acting as before to prevent motion.

If we attempt, as a matter of convenience, to assign an approximate numerical value to the loss by friction, we shall find it convenient to represent this loss as a percentage added to the load; and experience shows that it is a safe general rule to increase the load by 10 per cent for each sheave over which the fall leads and then to consider that this increased load is being lifted by a frictionless purchase. Accordingly, to find the power required on the hauling part, or (what is the same thing) the maximum tension on the rope, we add the percentage for friction as above, and divide by the number of parts at the movable block. (See § IV.)

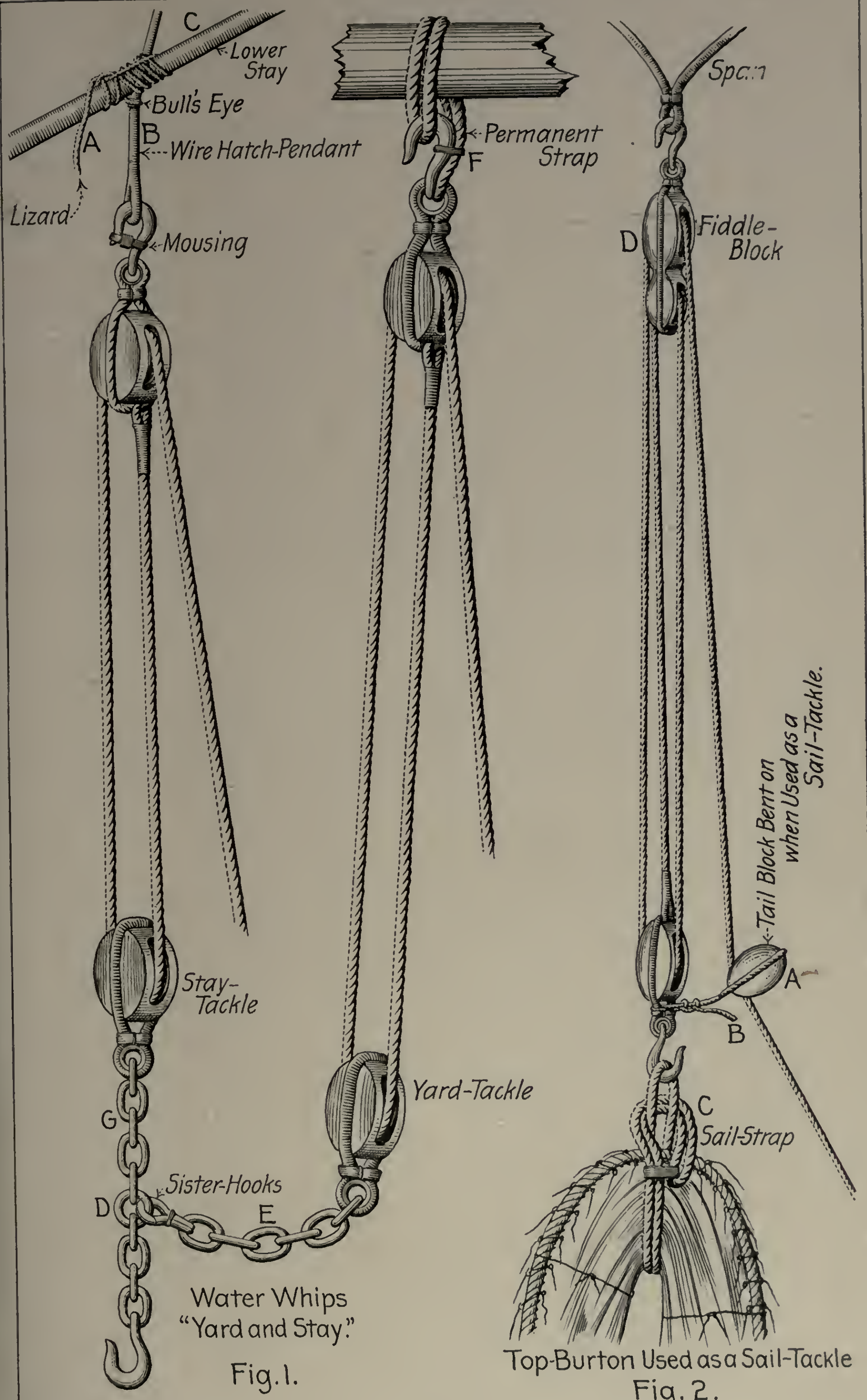
No attempt is made, in the above "Rule-of-Thumb," to take account of variations in speed due to variations in power applied, or of the fact that friction increases with the speed. The rule is for average working conditions, and includes a sufficient margin of safety to cover all practical cases.

It will be clear from the preceding that much power is wasted where the hauling part of a purchase is taken through an extra (fixed) sheave merely to give a fair lead. A familiar case of this is that in which a fall leading from aloft is taken through a block on deck to be manned or led to a winch. Such leads are often unavoidable; and even where not so, the gain in convenience may more than offset the loss of power; but it must not be forgotten that this loss of power is considerable. The same reasoning applies to an unnecessary sheave in the fixed block of a purchase, which has of course the same effect as an unnecessary sheave anywhere else.

If one tackle is attached to the hauling part of another, the power of the combination is the product of the powers of the tackles composing it.

It is important to observe that in tackles as in all other mechanical appliances, "what is gained in power is lost in speed." This is clearly brought out by a comparison of Figs. 1 and 2 of Plate **41**. In Fig. 1, a single whip, if the haul-

Plate No. 43.



Water Whips "Yard and Stay."

Fig. 1.

Top-Burton Used as a Sail-Tackle

Fig. 2.

Tackles in Use.

ing part moves through one foot, the weight at the other end moves through the same distance. Both space and power are equal at the two ends of the rope. In Fig. 2, a runner, the power is doubled at the block, but the block moves through only half the distance moved by the hauling part. And so at every sheave of a movable block. If the power is multiplied six times, as by a three-fold block, the hauling part must move through six feet to move the block one foot. This may be a very important point where space is limited.

Tackles are of value not only as multiplying power but as applying the power more smoothly and uniformly. So, too, in easing away, they prevent the surging which is almost unavoidable with a single part, and at the same time make it possible to lower more slowly and with much more exactness; since, as has been explained, the motion at the block of a purchase is only a fractional part of what is given on the fall. The greater the number of parts to the tackle, the greater the gain in this respect as well as in the power.

For heavy work with a three- or four-fold purchase, the fall should be rove with the hauling part leading from the middle sheaves of the blocks instead of from the outer ones. This involves a turn in the parts, but reduces the chance of slewing the blocks in their straps. For light purchases, it is a common practice to make the standing part fast to a becket worked into the strap. This will not answer for heavy work. If the standing part is to be made fast to the block, it should be taken around and secured between the block and the hook (Fig. 1, Plate **44**). It is a still better plan to make it fast to the weight to be lifted, close alongside the block, instead of to the block itself. The hauling part of a tackle should be kept as nearly as possible parallel to the other parts. A divergence from this line means a loss of power.

As the power of a tackle depends upon the number of parts at the movable block, we have the rule that whenever circumstances permit, the block having the greater number of parts—or in other words, the block from which the hauling part leads—should be attached to the weight to be moved. This rule is often disregarded because it is usually impracticable to take the hauling part from the lower block directly to the winch; and the most natural way of giving it a lead from the derrick-head is to place there the block of the tackle from which this part leads.

A better plan is to let the hauling part come from the lower block, and to take it up through an independent leading block at the derrick-head; thus preserving the full power of the tackle. In many cases it is necessary to use still another leader at the heel of the derrick.

§ III.

Tackles may be designated either according to the number of sheaves in their blocks; as, single, double, three-fold, etc.; or according to the purpose for which they are used; as, Yard-tackles, Stay-tackles, Fore-and-aft-tackles, etc. Still other designations, not so easily accounted for, are luff-tackles, gun-tackles, Spanish-burtons, etc.

Tackles are almost invariably rove of manila rope.

Plate **41** shows diagrammatically various forms of tackles with the theoretical gain in power due to each and the approximate actual gain when friction is taken into account. Plates **42**, **43** and **44** illustrate certain common applications of tackles on ship-board.

A Single-whip (Fig. 1, Plate **41**). A single block, fixed.

A Runner (Fig. 2, Plate **41**). A single block, movable.

A Whip and Runner would be a whip hooking to the hauling part of a runner.

A Gun-tackle (Figs. 3 and 4, Plate **41**). Two single-blocks.

A Luff (Figs. 5 and 6, Plate **41**). A single and double-block. Sometimes called a "watch-tackle."

A Two-fold Purchase (Figs. 7 and 8, Plate **41**). Two double-blocks.

A Three-fold Purchase, of two treble-blocks, is about the heaviest purchase used on ship-board.

The above are all the purchases in common use. It will be noted that in all cases where the two blocks of a purchase are alike, the hauling part leads from the block to which the standing part makes fast, while in cases where one block has an extra sheave, the hauling part leads from this block and the standing part from the other. To get the full power of any of the purchases, the block from which the hauling part is led must be secured to the object to be moved.

A Spanish Burton (Fig. 9, Plate **41**). Two single-

Plate No. 44.

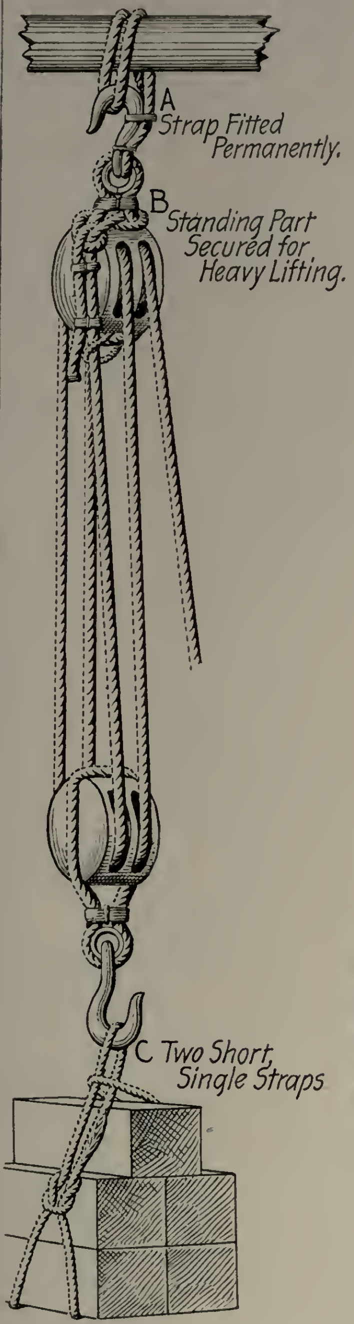

A
Strap Fitted Permanently.
B
Standing Part Secured for Heavy Lifting.
C
Two Short, Single Straps

Fig. 1.
Two-Fold Tackle.

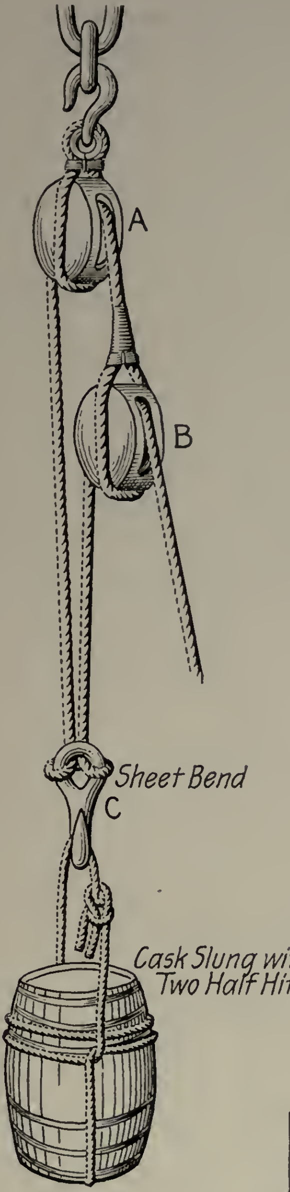


Fig. 2.

Single
Spanish Burton.

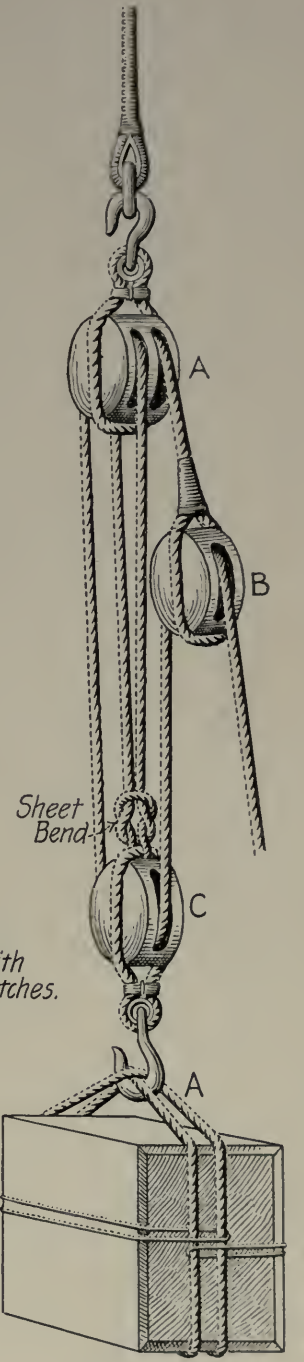
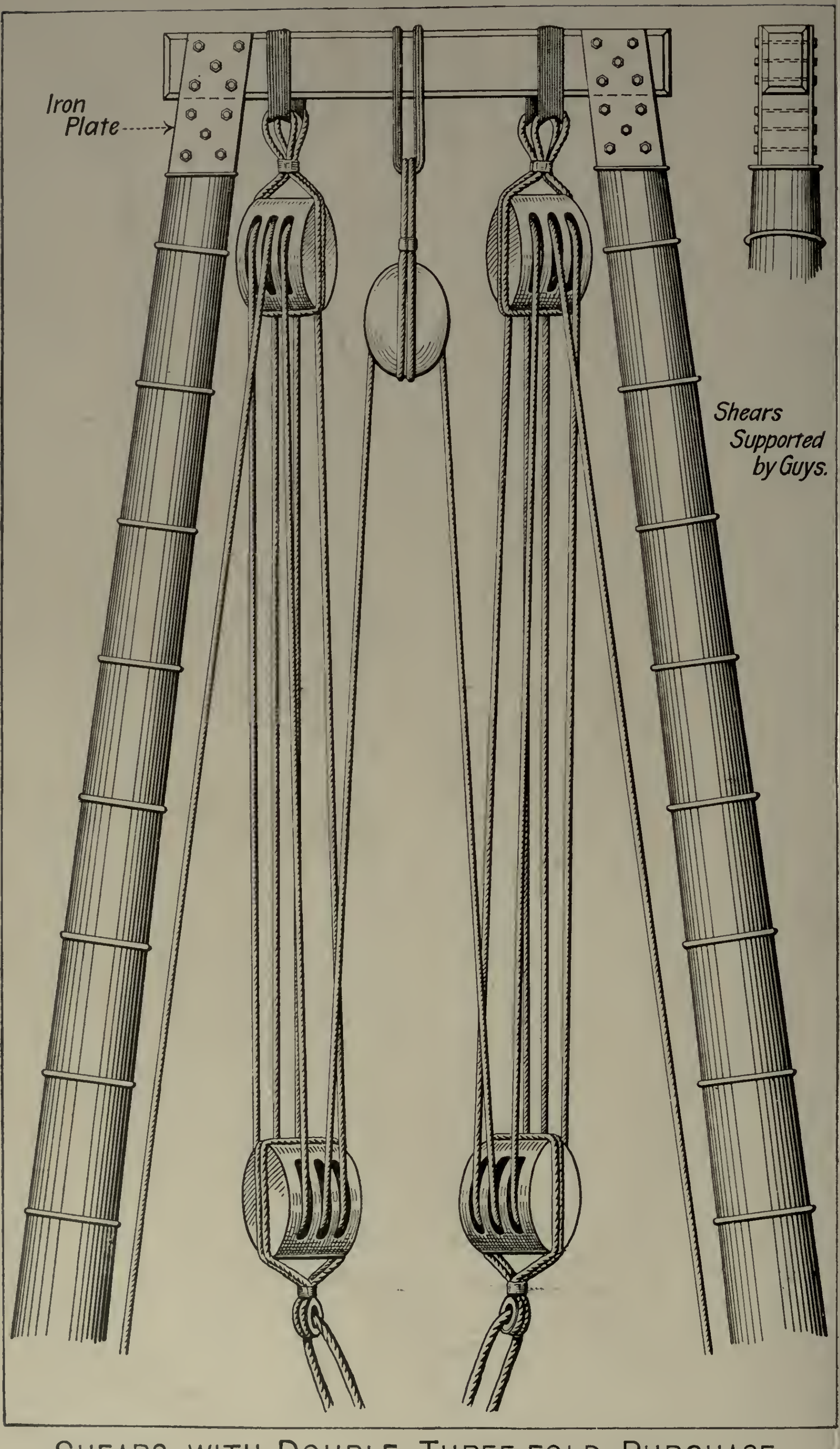


Fig. 3.
Double Spanish Burton.

TACKLES IN USE.

Plate No. 45.



SHEARS WITH DOUBLE THREE-FOLD PURCHASE FOR HANDLING HEAVY WEIGHT.

blocks, one fixed the other movable, with a bight of the fall secured to the object moved.

A Double Spanish Burton (Fig. 10, Plate **41**). A fixed double and two movable single-blocks, which are made fast to the object to be moved.

A Bell's Purchase (Fig. 11, Plate **41**). Four single-blocks, two fixed and two movable, with a bight of the fall stopped to one of the movable blocks.

A Luff upon Luff (Fig. 12, Plate **41**). The double-block of one luff hooking to the hauling part of another.

Plate **45** shows a special purchase which may be used for very heavy weights. The tension of the various parts of the fall is partially equalized, by applying the power to both ends.

A Deck-Tackle is a heavy purchase, usually two-fold, used in handling ground-tackle, mooring ship, and, generally, for heavy work about the decks.

Pendant-Tackles are heavy two-fold purchases kept hooked to the lower pendants and designed primarily for setting up lower shrouds or for steadying the masts if the rigging becomes slack. They are also used, like deck-tackles, for general work about the decks.

Yard-Tackles are used on the lower yard-arms for hoisting in provisions, stores, etc. Any tackle used on the yard is for the time being a "yard-tackle" but the term is applied in a more specific way to certain rather heavy two-fold purchases kept for handling weights too heavy for a "water-whip."

Stay-Tackles are hooked to the collar of the lower stay or some other point aloft where they plumb the deck nearly amidships, for hauling in and landing on deck articles hoisted by the yard-tackle; or, conversely, for lifting articles to be hauled out and lowered over the side by the yard-tackle.

Fish-Tackles are heavy two-fold or three-fold purchases used for getting the anchor on the bow. They hook at the head of the fish davit and to the balancing-link on the shank of the anchor.

Top-burtons are tackles hooked to the topmast pendants and used for setting up rigging, for securing lower yards when handling heavy weights, and for other purposes requiring a tackle from aloft. They are usually rove as luffs, with a fall of sufficient length to be led out on deck when the lower blocks are also on deck.

Water-whips are gun-tackle purchases used as yard-tackles for hoisting in moderate weights (Fig. 1, Plate **43**).

A Sail-Tackle is a tackle used for sending a topsail aloft for bending. A top-burton is generally used for this (Fig. 3, Plate **43**).

Relieving-Tackles are used to assist or replace the tiller ropes in steering. One block hooks to the tiller, the other to the ship's side.

Stock- and Bill-Tackles are used in getting the anchors on and off the bows in old-fashioned ships. They hook to straps on the stock and bill of the anchor respectively, and lead across the deck.

Thwartship-Tackles are used on the heads of boat-davits for rigging in and out. In a more general sense the term is applied to any tackle leading across the deck.

Jiggers are light tackles used for miscellaneous work about the deck. They are commonly rove as luffs.

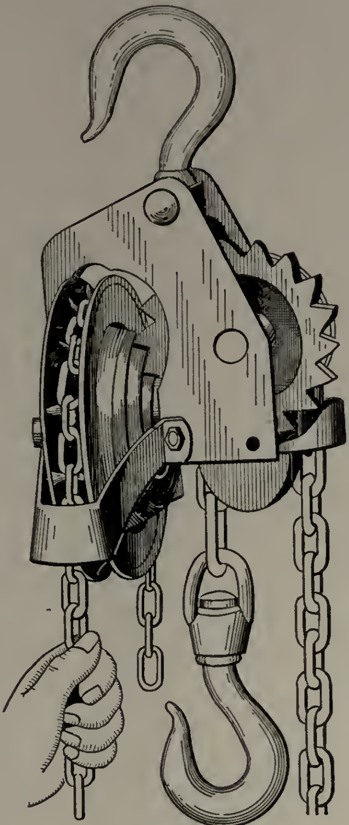
Hatch-Tackles are used at hatches for hoisting and lowering stores.

Differential and Duplex Purchases.

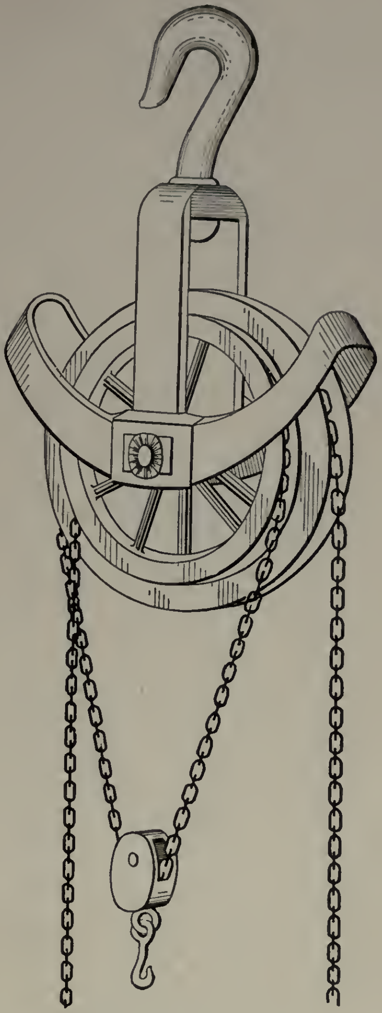
In a differential purchase (Fig. 3, Plate **46**), an endless rope is taken over two sheaves of slightly different diameters which are keyed to the same shaft and revolve together. A movable block to which a weight may be attached is hung in the bight of the endless rope. If power is applied to one of the parts leading from the larger sheave, the rope is unwound from the sheave, but is at the same time wound up on the slightly smaller sheave alongside. Thus the change in the length of the bight which carries the movable block is very slight, for a great distance moved by the hauling part. By a simple mathematical demonstration, which would be out of place here, it can be shown that the ratio of the power applied, to the power on the movable block, is equal to the difference in the diameters of the sheaves of the fixed block divided by the larger diameter.

A Duplex Purchase (frequently called a Differential) is shown in Fig. 2, Plate **46**. It consists of two wheels at right

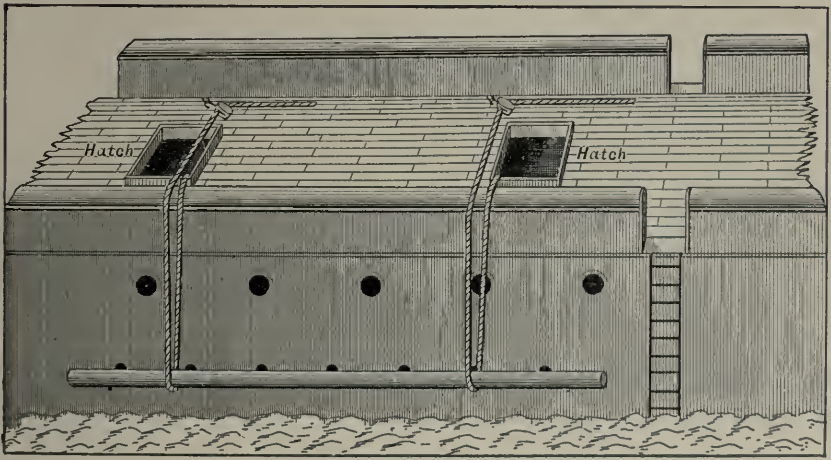
Plate No. 46.



Duplex Purchase.



Differential Purchase



Parbuckling a Spar on Board Ship.

DIFFERENTIAL PURCHASES — PARBUCKLING.

angles to each other, one of which has a cogged rim engaging a series of cams on the face of the other wheel. The details are made clear by the figure. The power here may be made almost anything that is desired, by proper design of the cams and gearing. In any given case it may be determined theoretically (without friction) from the ratio of the distance moved by the power to that moved by the weight.

§ IV. PRACTICAL RULES FOR ROPES, BLOCKS AND TACKLES.

NOTE.—These rules are the result of experience, not of theory, and all involve a liberal margin of safety.

1. **To find the safe working load for a rope of given size.** (Hemp, Manila, or Coir.)

Square the circumference in inches and divide by 7 for the load in tons.

2. **To find the size of rope for a given working load.**

Multiply the load in tons by 7 and take the square root of the product for the circumference of the rope in inches.

3. **To find the size of rope when rove as a tackle to lift a given weight.**

Add to the weight one-tenth of its value for every sheave to be used in hoisting. This gives the total resistance, including friction. Divide this by the number of parts at the movable block, for the maximum tension on the fall. Reeve the fall of a size to stand this tension as a safe working load.

EXAMPLE:

To lift 10 tons with a three-fold purchase, the fall of which, coming from the upper block, is taken through an extra sheave on deck for a fair lead. Required the size of fall needed.

Total resistance including friction $= 10 + 7 \times \frac{10}{10} = 17$ tons.

Maximum tension on fall $= \frac{17}{6} = 2.8$ tons.

Size of fall (Rule 2) $= \sqrt{7 \times 2.8} = 4.4$ inches (nearly).

4. **To find the weight which a given purchase will lift with safety.**

Find the safe working load for the rope to be used. (Rule 1.)

Multiply this by the number of parts at the movable block. This gives the total resistance including friction.

Multiply the total resistance by 10 and divide by 10 + the number of sheaves used. The result is the weight that may be lifted.

EXAMPLE:

To find the weight which may be lifted by a fall of 4½-inch manila rove as a three-fold purchase, the fall of which leads from the upper block through an extra leader on deck.

Safe working load $\frac{4.5^2}{7} = 2.9$ tons.

Total resistance including friction $6 \times 2.9 = 17.4$ tons.

Weight to be lifted $\frac{17.4 \times 10}{10 + 7} = \frac{174}{17} = 10.2$ tons.

5. **To find the safe working load for wire-rope.**

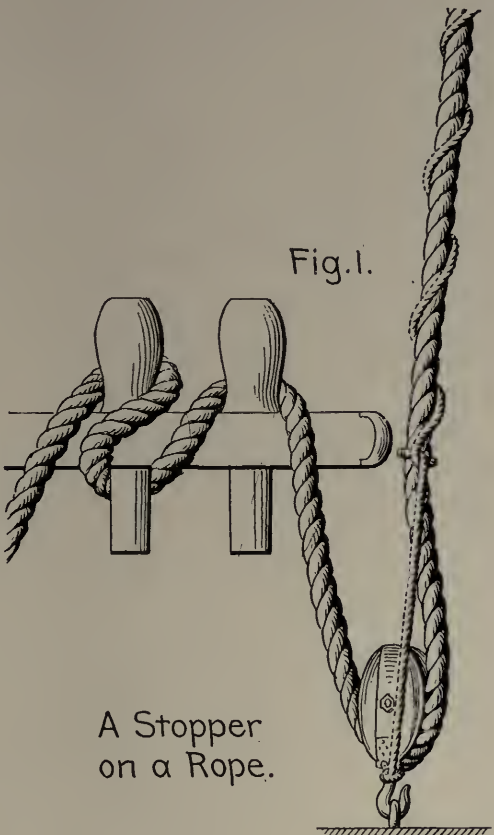
Take one-sixth the breaking strain as given by the manufacturers for the particular brand of wire in use. (See Table at end of Chapter on "Rope.")

It may generally be assumed that the safe load for a well-made block is in excess of that of any hemp or manila rope that it will reeve. This, however, is not always true of the *hook*, which is almost invariably the weakest part, and often gives way under strains for which the block is otherwise amply strong. The strength of the hook is therefore the measure of the strength of the block. (See Table appended, of breaking strains of hooks and shackles.) The difficulty here comes from the tendency of the hook to open out;—a tendency which should be guarded against, in heavy work, by careful "mousing" of the hook—preferably by an iron link. *Even when moused, hooks are less reliable than shackles, and these should be fitted to all heavy blocks.* Where circumstances admit of it, lashings should be preferred to iron-work for lifting heavy weights, on the ground that rope is more trustworthy, for a given calculated strength, than iron or steel.

For the following Table of breaking strains of Hooks and Shackles, the author is indebted to the Boston and Lockport Block Company, for whom the tests upon which the Table is

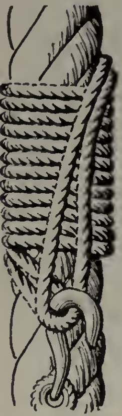
Plate No. 47.

Fig. 1.



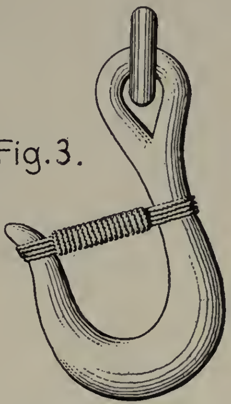
A Stopper on a Rope.

Fig. 2.



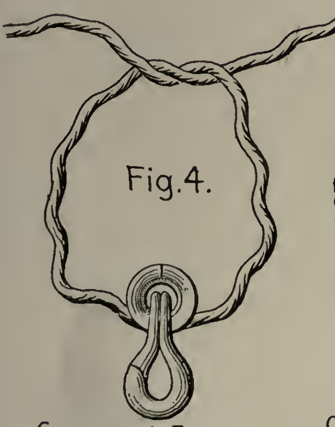
Strap on a Rope. (For Hooking a Tackle.)

Fig. 3.



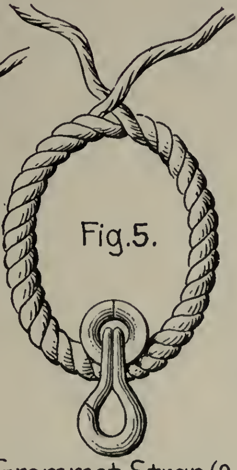
Mouse a Hook.

Fig. 4.



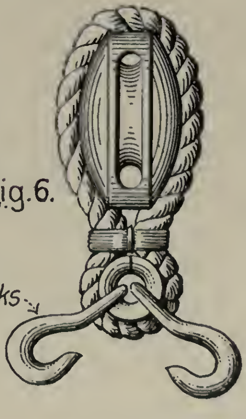
Grommet Strap (1.)

Fig. 5.



Grommet Strap (2.)

Fig. 6.



A STOPPER ON A ROPE, HOOKING A TACKLE, ETC.

based were made at the Watertown Arsenal. The hooks and shackles tested were of the ordinary commercial form. The diameter given is that of the metal at the back of the hook and the sides of the shackle.

TEST OF HOOKS.

Diameter of Metal of Hook	Broke at	Remarks
½ inch	2,385 lbs.	Hook partly straightened, then fractured across the back. Fibrous.
¾ "	4,130 "	
1 "	10,315 "	
1¼ "	14,510 "	
1½ "	20,940 "	
1¾ "	27,420 "	
2 "	38,100 "	

TEST OF SHACKLES.

Diameter of Metal of Shackle	Broke at	Remarks
1¼ inch.	53,200 lbs.	Across the eye. Fibrous.
1½ "	119,980 "	Eye in front of pin. Fibrous.
1¾ "	136,100 "	Across the eye. Fibrous.
2 "	129,700 "	" " " (inferior to preceding).

These tests show the very great superiority of shackles as compared with hooks.

For a safe-working load on a hook or shackle, from 40 to 50 per cent of the breaking strain may be taken.

CHAPTER VII.

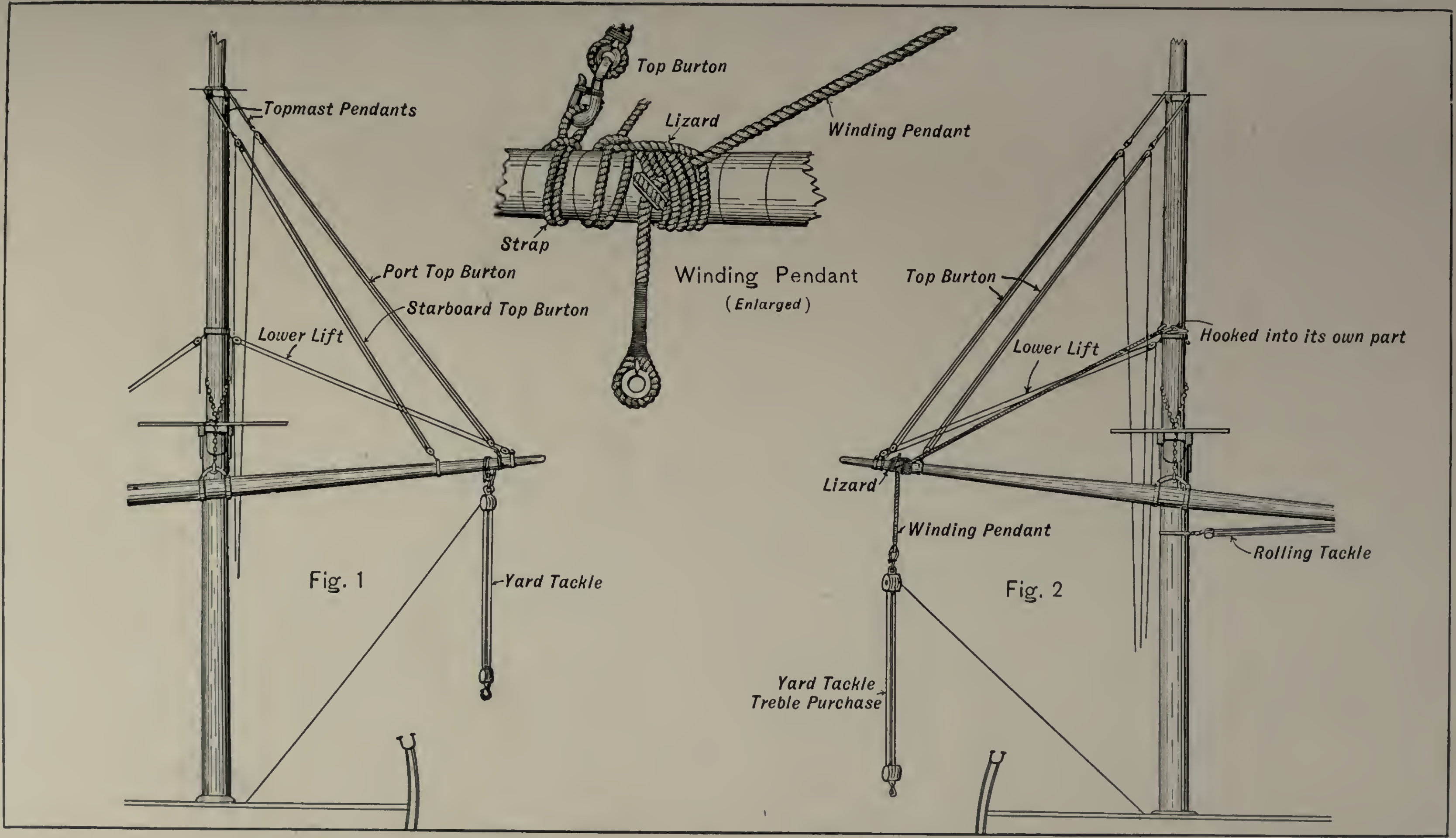
HANDLING HEAVY WEIGHTS.

Where masts and yards are available, as in sailing ships and steamers with auxiliary sail power, the problem of handling ordinary weights presents no great difficulty. The lower yards are used as derricks with suitable support from the mast by lifts and burtons. The principles which govern the rigging of these are identical with those discussed in Chapter V; and the practical details are shown in Plate **48**.

For moderate weights—not exceeding half a ton—a lower yard supported by the lift and one or two top-burtons as in Fig. 1, Plate **48**, gives ample security. It will be noted that the purchase is hooked midway between the burtons. With a somewhat greater weight, the yard, while supported as before, is relieved of much of the weight by a "winding" pendant from the topmast, just above the lower cap, hauled out to the yard-arm by a lizard or a tackle (Fig. 2, Plate **48**). The use of a tackle has the advantage over a lizard that it admits of easing away to plumb a hatch or any other point at which it may be desired to land the weight; thus doing away with the necessity for a "stay-tackle." The principle here illustrated is of very general application in handling weights.

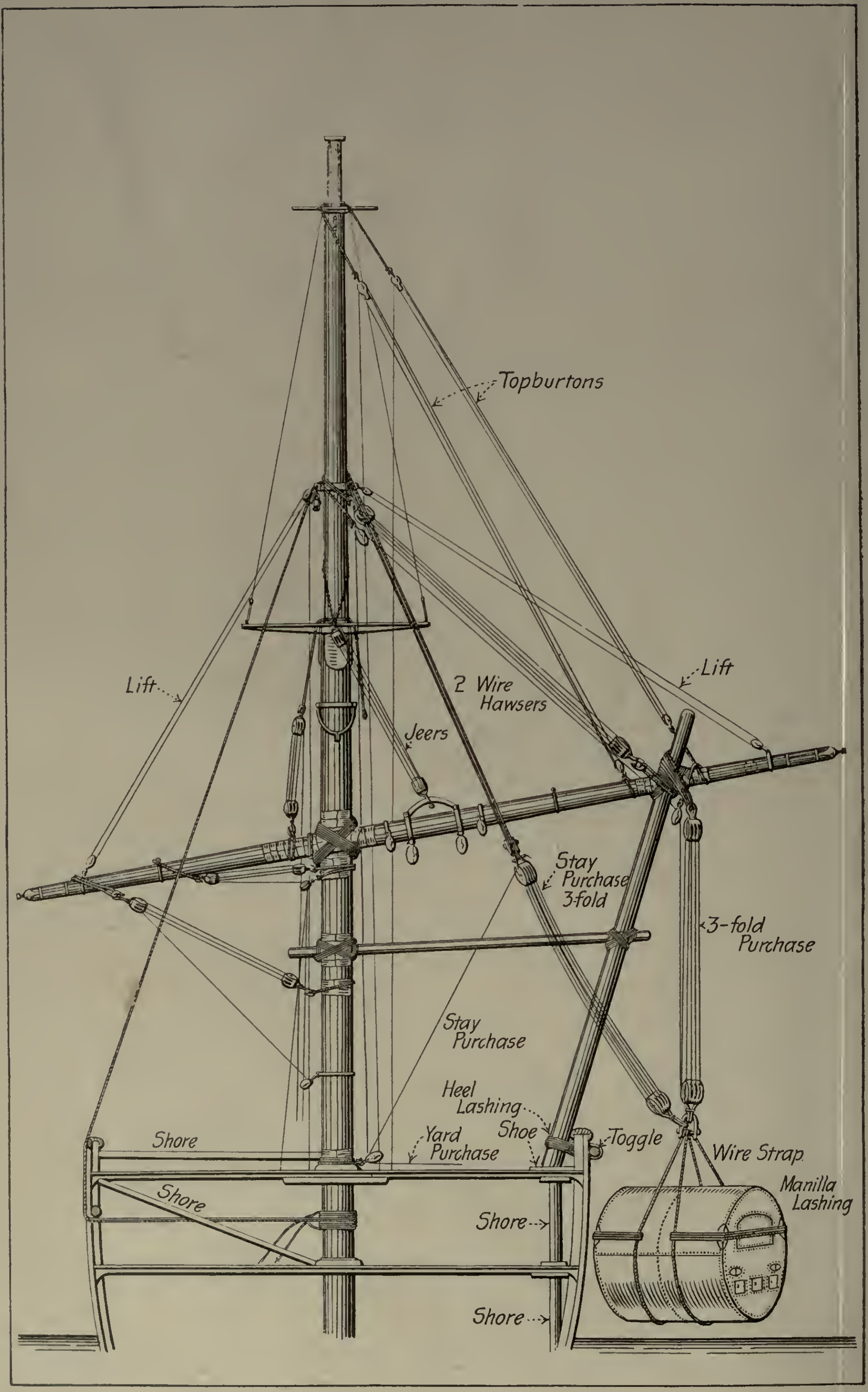
Where several purchases are used to support the yard, it is important that they should divide the work as equally as possible. It will be understood from what has been said in Chapter V that they cannot divide the strains exactly unless they have identical leads; but they can be made to act together, each bearing its proper proportion of the total strain, *unless the yard is to be swung with the weight hanging from it.* This should be avoided if possible, and if it is to be done it should be clearly recognized that there is no hope of keeping anything like an equal strain on a number of purchases hooked at different points and leading off at different angles. Whatever support the yard is to have should in this case be concentrated at a single point and if possible in a single tackle. A good pendant-

Plate No. 48.



HANDLING WEIGHT BY A LOWER YARD.

Plate No. 49.



LOWER YARD RIGGED FOR HANDLING VERY HEAVY WEIGHT.

tackle from the topmast head hooking to a strap close to that of the yard-tackle will usually give ample support for almost any weight that would be handled in this way; and if the lift is kept slack the yard may be braced with safety. If it is thought necessary to use two tackles, they may be hooked to the ends of a good strap rove through a thimble or a single block lashed to the yard. The rendering of this strap will keep the tackles taut alike as the yard is swung. In most cases the necessity for swinging the yard may be avoided by the use of a "stay-tackle" hooked at such a point aloft and amidships that it will bring the weight in as the yard-tackle is eased away. If, in addition to the yard and stay, another tackle is used hooking to a pendant from the fore topmast head (supposing that the main yard is in use), the weight may be landed at any point that is desired. It will be seen that the principle of the span is involved in this use of two purchases or pendants; and care should be taken not to let the angle between them become too great.

Wherever a yard is used as above described, the inward thrust along the yard must be considered. This is taken principally by the truss, but may be thrown upon the mast by hauling taut the opposite lift and using a "rolling tackle" from the quarter of the yard to a strap around the mast. If the weight to be handled is very great, the yard should be unkeyed from the truss, lowered as much as the conditions admit, and lashed to the mast. Plate **49** shows the manner of rigging the yard for an extreme case, where the weight to be handled is such as to call for every possible precaution. Such an arrangement as this would not be practicable on a modern ship, but it is given here because of the fulness with which it illustrates the principles involved in handling weights. Knowing the weight to be dealt with and the angles between the various spars and tackles used, we can calculate the strain upon any part of the system and the size of the rope required to meet it, by the rules of Chapters V and VI.

It is often convenient to use a span between two masts. This may, indeed, be the only way to plumb a hatch. In such a case the pendants must be secured as high as possible; since the smaller the angle between them, the less the tension to which they are subjected by a given weight. (See Chapter V.)

Modern ships as a rule have no yards which can be utilized for handling weights, but are fitted with booms swinging about heavy pivot-bolts on the mast, and supported by topping-lifts and guys which admit of plumbing any point within a considerable range on deck and alongside. There is no difference in principle between such a boom and a yard rigged and used as has already been described, except that the yard has the characteristics of a long boom used nearly level. The cargo booms of merchant vessels and the boat-booms or cranes of men-of-war, are usually heavy enough for weights up to three or four tons, while the cranes of a battleship are designed to handle launches weighing six or seven tons.

The range of power of such a boom may be considerably extended by the use of a spar as in Plate **50**, to take the direct downward thrust, the deck under the shoe of the spar being well shored up. This takes a large part of the tension from the topping-lift. It is well to block up under the pivot-bolt, or to unkey the boom and step the heel upon the deck. The boom itself may be strengthened by "fishing"; that is, by placing lighter spars along its length and lashing all securely together. If the boom is not conveniently situated for the work to be done, it may be transported to the point where it is needed and supported there by topping-lifts and guys, the heel being placed in a shoe and the deck below shored up as in all similar cases (Plate **51**).

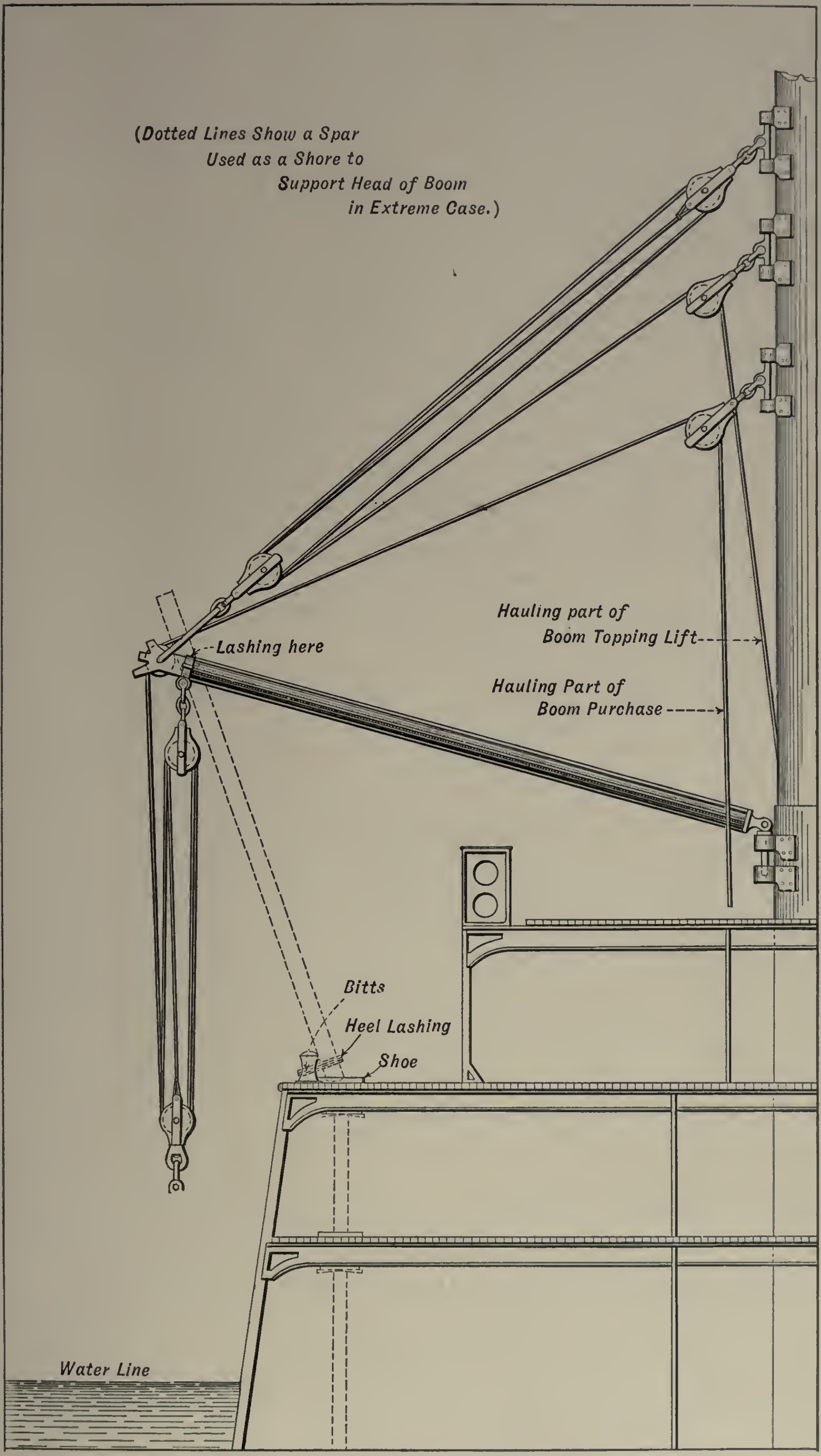
If the boom is to be topped up or lowered with the weight hanging from it, the strength of the topping-lift must be calculated for the lowest position the boom will occupy, as this is the one in which the demand upon it will be a maximum. It must be remembered also that there will be a much greater tension on the fall of the topping lift than if the boom were fixed. This is due to the resistance of friction which must be added to the theoretical load as soon as the system is set in motion.

The anchor-davit may sometimes be utilized, assisted by a topping-lift from aloft if the foretopmast is so situated as to make this feasible.

Where the object to be handled is of such a nature as to admit of parbuckling, this is a simple and convenient method to use especially on a ship of low free-board (Plate **46**).

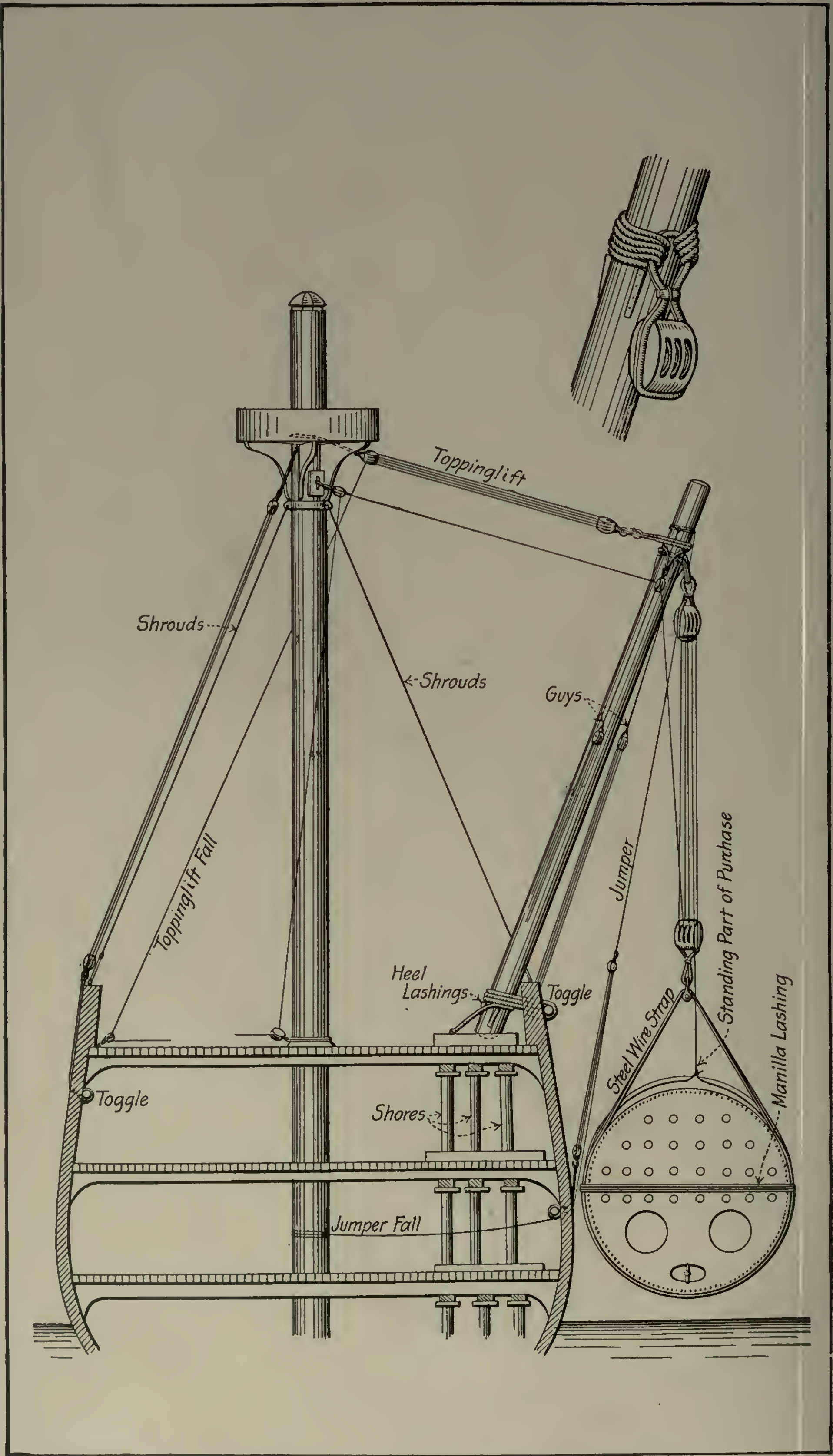
Where the ordinary resources of a ship are insufficient for the work in hand, a derrick or shears must be rigged, the ma-

Plate No. 50.



BOOM FOR HEAVY WEIGHTS.

Plate No. 51.



RIGGING A DERRICK FOR A HEAVY WEIGHT.

terials being obtained where they can be found. Plate **52** shows the details of shears.

The heels of such derricks and shears are stepped in shoes, which must be large enough to distribute the weight over a number of beams, and the decks below are well shored up. The shoes are lashed to prevent slipping, and in the case of shears are held from spreading by a thwartship tackle. The shear-head lashing is sometimes passed with figure-of-eight turns, but the method shown in Plate **52** is better. The lashing, being passed with the legs laid alongside each other, tautens as they are opened out. The shear-head is supported by topping-lifts and inclined as much as may be necessary. The more nearly upright the legs can be kept, the greater will be the proportion of the weight supported by the thrust of the spars and the smaller the demand upon the topping-lifts. The greater the distance from the heel of the derrick to the point where the guys set up, the less the strain upon the guys.

If the weight has first to be lifted from between-decks and afterward put over the side, it will usually be necessary to land it between the two operations. It is true that derricks (not shears) are constantly used to lift weights and swing them around, but these are derricks properly fitted and supported for it. With improvised arrangements and a heavy weight, it is wiser to land the weight and move the derrick or shears.

If it becomes necessary to rig the shears or derrick at a point where no mast is available for giving a lead to the topping-lift or guys, a mast may be improvised; the topping-lift being secured to this or led over it (through a good block) and set up as far from the mast as possible. Where the guys are to lead athwartships, an outrigger may be used on the off side of the ship, secured by a hawser dipping under the keel, and steadied by good lines forward and abaft.

If not entirely sure that everything is going to hold, it is well to block up from deck to deck with heavy planks crossing the hatches under the object as it is hoisted from below, and following up as close to it as possible, so that it cannot drop more than a few inches if anything gives way. So in transporting it from the hatch to the rail it should be lifted only just high enough to clear the deck. If it must be raised for the purpose of clearing the rail, skids may be used from the hatch and the weight partly lifted and partly skidded across.

If the blocks and falls that must be used are not heavy enough for the work required, with the fall rove in the usual way, resort may be had to the form of a tackle shown in Plate **45**. Here we have two tackles so far as power is concerned, but by making the fall continuous and using both ends of it for hauling, we distribute the friction more uniformly, since there is no "standing part." Another advantage is, that in cases where two distinct tackles are used there must be times when one will lag behind, leaving the weight entirely on the other. This cannot happen where the fall is continuous, as in Plate **45**. It is thus possible with blocks and falls of a given size, to handle a weight considerably heavier than would otherwise be safe.

All blocks should be thoroughly overhauled, and careful calculations made of the stresses to which all parts of the system are to be subjected. Shackles or lashings should be substituted for hooks whenever it can be done, and in other cases the hooks should be securely moused. Particular attention should be given to the running of winches to see that no surging is allowed in either hoisting or lowering. A heavy surge will nearly or quite double the strain.

Finally, in reeving the purchases, leading the falls, etc., attention should be given to the principles explained and the rules laid down in Chapters V and VI.

Plates **42**, **43** and **44** illustrate a variety of methods of slinging weights, hooking tackles, etc.

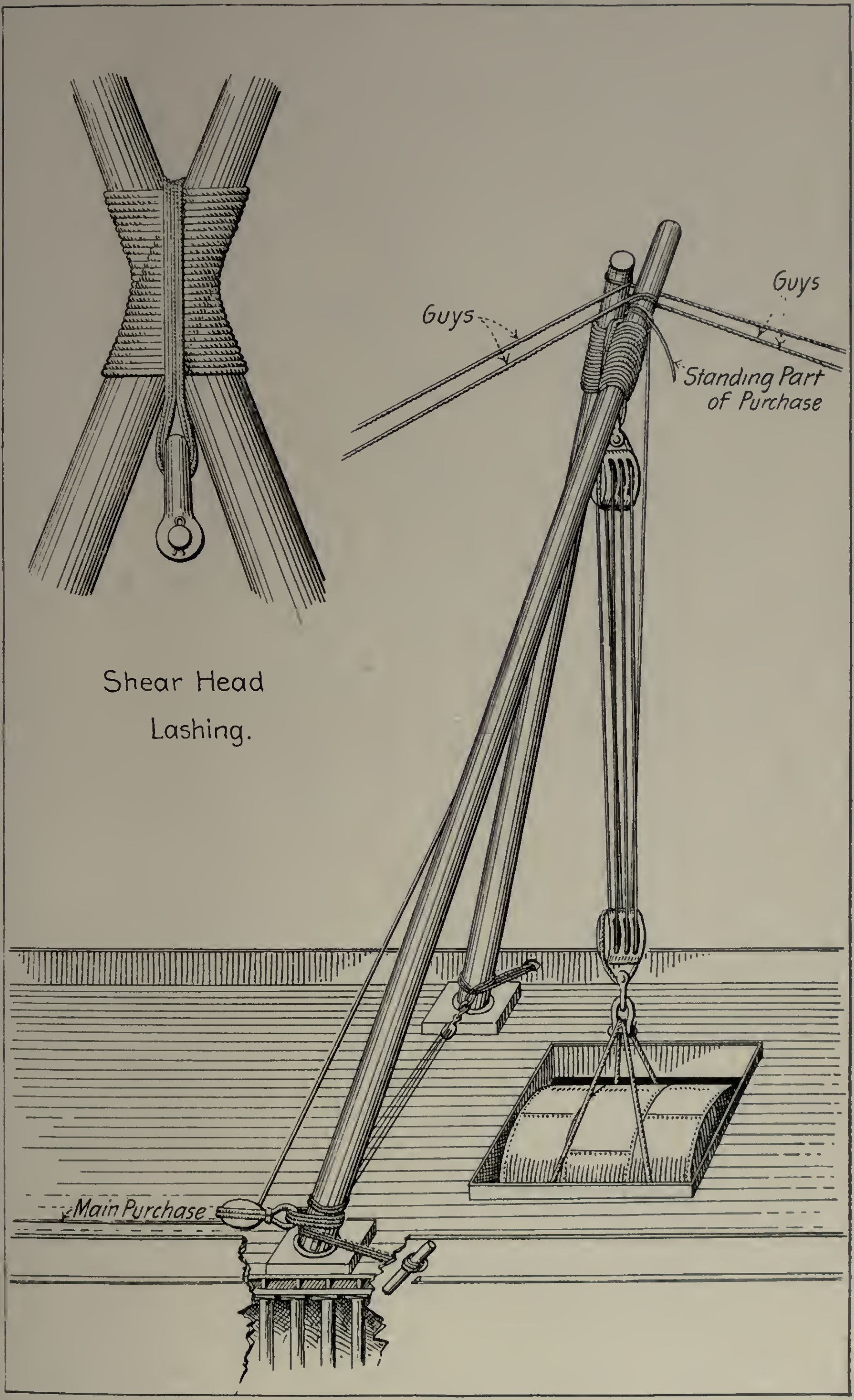
§ II. PRACTICAL EXAMPLES IN HANDLING WEIGHTS.

(See Rules of Chapters V and VI.)

As the Rules above referred to are only approximations, it is unnecessary in applying them to work with mathematical exactness. In the solutions which follow, small fractions are neglected, but care is taken to keep, upon the whole, on the side of safety.

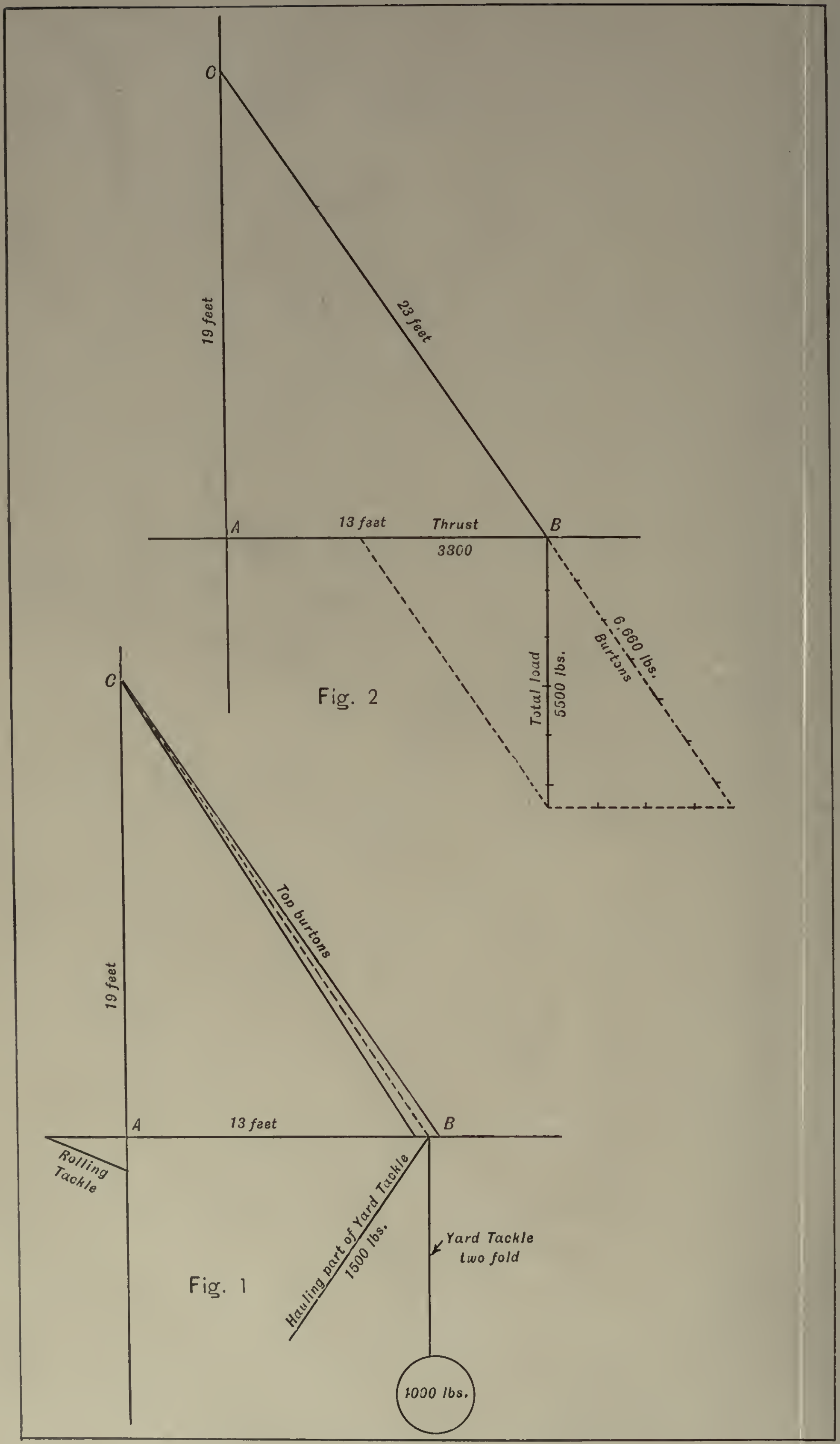
In many cases, a close estimate of the stresses can be made by the eye, without calculation, and it is well to accustom the eye to such estimates by an occasional test. Most of the calculations which are required can be made mentally, if the rules are well in mind. In important cases, however, it is worth while to

Plate No. 52.



Shears For Handling A Heavy Weight.

Plate No. 53.



HANDLING WEIGHTS BY A YARD.

make a careful sketch, to scale, and this will be found to involve very little trouble in comparison with the importance of the results depending upon it.

1.

A weight of 4000 lbs. is to be lifted by a yard, as in Plate **53**, the yard-tackle to be a two-fold purchase, with the hauling-part leading from the upper block to the deck. Two top-burtons of 2-inch manila are available for supporting the yard. It is required to calculate the size of rope required for the yard-tackle, and to determine whether the top-burtons are heavy enough for the work.

(a) Total resistance of main purchase including friction $= 4000 + \frac{5}{10} 4000 = 6000$ lbs.

Maximum tension on fall $= \frac{6000}{4} = 1500$ lbs. $=$ ¾ ton (nearly).

Size of rope for ¾ ton $= \sqrt{7 \times 0.75} = 2\frac{1}{4}$ inches (about).

(b) The load on the yard is the actual dead weight, plus the tension on the hauling part.[1] $= 4000 + 1500 = 5500$ lbs.

To find the tension on the lift, we construct the parallelogram of forces, as in the figure.

Tension on the topping-lift $= 6600$ lbs.

Or we may note the length of the lift and of the mast (from A to C), and determine the tension by a proportion, thus:

Length of mast, AC = 19.
Length of lift, BC = 23.
Downward tension at B = 5500 lbs.
$\frac{\text{Tension on lift}}{5500} = \frac{23.}{19.}$
Tension on lift = 6600 lbs.

It should be possible to estimate this tension rather closely by the eye, without calculation, since it is easily seen that the lift if not far from 1¼ times as long as the mast.

The tension will be divided between two top-burtons, each of which has three parts. As the yard is not to be moved, friction does not enter the problem. Each part will have to support one-sixth of the total tension, or, 1110 lbs. (½ ton).

---

[1] Strictly speaking, only the vertical component of the tension on the hauling part should be included here, but it is convenient and safe to count it as if the lead of the hauling part were vertical.

To find the safe load for the rope of which the burtons are rove. Safe load for 2″ rope $= \frac{2 \times 2}{7} = 0.6$ ton (nearly). (§ IV, Chap. VI.)

As this is more than the tension found above for each part, the burtons are heavy enough for the work.

(c) To determine the thrust on the yard.

Referring to the parallelogram of forces in Fig. 2, we have, Thrust = 3800 lbs.

Or we may calculate it by proportion, as follows:

$$\frac{\text{Thrust on yard}}{5500} = \frac{AB}{AC} = \frac{13}{19}$$

Thrust = 3800 (about).

Here again it should be possible to make a close estimate by the eye, without calculation.

This thrust is supported by the truss, the lift, and the rolling tackle. By unkeying the truss and slacking the lift we may throw it entirely on the rolling tackle, which we will assume to be a two-fold purchase with the double block hooked to the yard. This gives 5 parts to divide the thrust.

Tension on each part = 760 lbs. = 0.33 ton.

Size of fall for this tension $= \sqrt{7 \times 0.33} = \sqrt{2.3} = 1\frac{1}{2}$ ins. (about).

NOTE.—This assumes that the rolling tackle is parallel with the yard. If the strap on the mast is below the yard, we find the tension on it by the parallelogram of forces.

2.

To lift 12 tons by sheers, as in Plate **54**.

Sheer-head Purchase.—Three-fold, with the hauling part leading from the upper block, parallel to the sheer legs, and through a leader on deck. Two (single) guys are used, making an angle of 30° with each other.

Total resistance $= 12 + \frac{7}{10} 12 = 20.5$ tons.

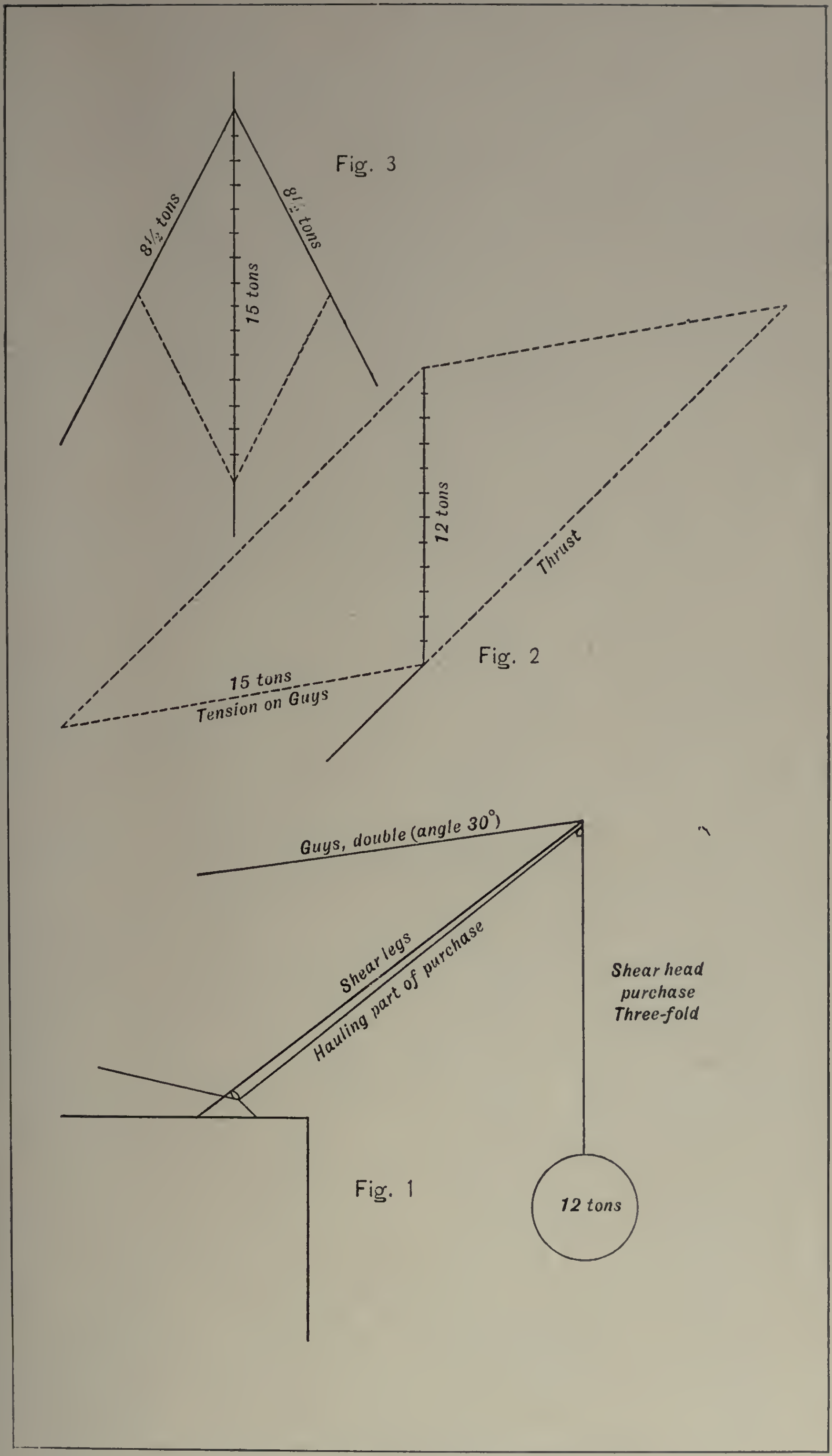
Maximum tension on fall $= \frac{20.5}{6} = 3.5$ tons.

Size of fall required $= \sqrt{7 \times 3.5} = 5$ inches (nearly).

To find the tension on the sheer-head, we neglect the tension on the hauling part of the sheer-head purchase, because this part leads parallel to the sheer-legs (where it adds to the thrust).

Load on the sheer-head = 12 tons.

Plate No. 54.



HANDLING WEIGHTS BY SHEARS

Plate No. 55.

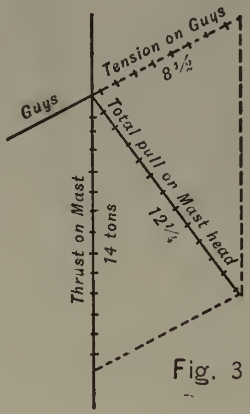


Fig. 3

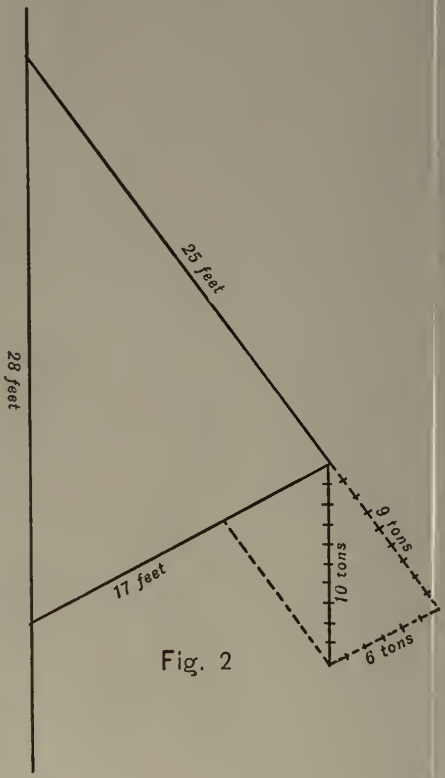


Fig. 2

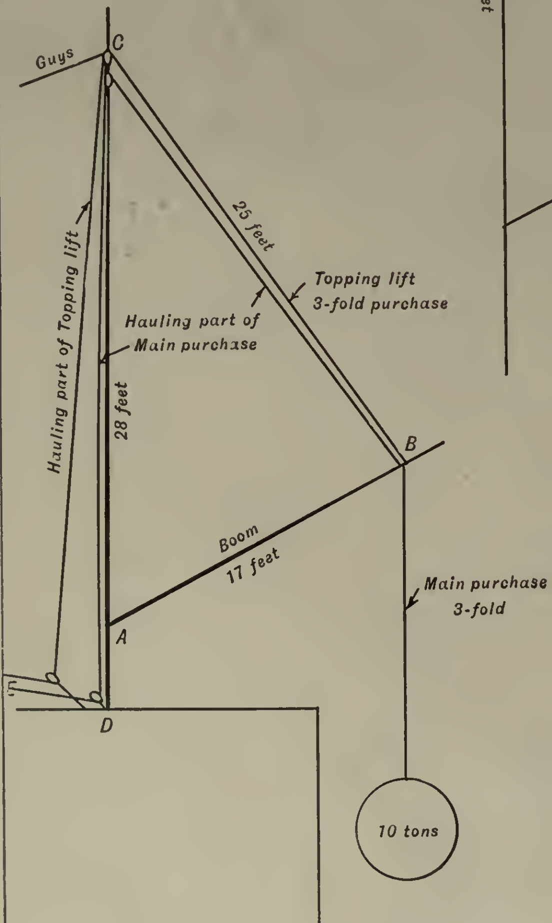


Fig. 1

HANDLING WEIGHTS BY A DERRICK.

By the parallelogram of forces we find,

Total tension on the guys = 15 tons. (Fig. 2.)

The tension on each guy = 8.5 tons. (Fig. 3.)

The size of rope to support this tension,

$= \sqrt{7 \times 8.5} = 8$ inches (nearly).

8-inch hawsers are required for the guys by the above rules. It should be noted, however, that these rules are formulated for conditions very different from those of the present case and that they involve a factor of safety which is unnecessarily large for a standing rope to be used for a short time. For a case of this kind, we may safely reduce our multiplier to 5. Thus:

Size of rope $= \sqrt{5 \times 8.5} = 6\frac{1}{2}$ inches (about).

3.

It is required to lift a 10-ton boiler by a derrick as in Plate **55**, the boom to be topped up for landing the weight on deck.

Main purchase. Three-fold, the hauling part leading from the lower block, up through a leader at the boom end, then through a leader at the masthead, then through a leader on deck.

Total number of sheaves = 9.

Number of parts at the movable block = 7.

Topping-lift. Three-fold, the hauling part leading from the upper block, and through a leader at the foot of the mast.

Total number of sheaves = 7.

Number of parts at the movable block = 6.

(a) To find the size of fall for the main purchase.

Total resistance including friction $= 10 + \frac{9}{10}\,10 = 19$ tons.

Maximum tension on fall $= \frac{19}{7} = 2.75$ tons.

Size of fall required $= \sqrt{7 \times 2.75} = 4\frac{1}{2}$ inches (nearly).

(b) To find the size of fall for topping-lift.

The load on the boom is the dead weight of the boiler alone, diminished somewhat as a result of the fact that the standing part of the main purchase leads up to the masthead. It is safe and convenient, however, to consider the whole weight as hanging from the boom. In resolving this along the lines of the lift and the boom we take the boom at its lowest point, this being the point at which the load on the lift will be a maximum.

Resolving the forces (Fig. 2).

Load on topping-lift due to weight = 9 tons.

Or thus,

$$\frac{\text{Load on lift}}{\text{Weight}} = \frac{\text{Length of lift}}{\text{Length of mast}} = \frac{25}{28}$$

Load on lift $= 9.$ tons.

This could be estimated closely by the eye.

As the boom is to be topped up, we must add the resistance due to friction, in calculating the strength of fall required.

Total resistance on topping-lift including friction,

$$= 9 + \frac{7}{10} 9 = 16.3 \text{ tons (nearly).}$$

Maximum tension on fall of topping-lift $= \frac{16.3}{6} = 2.75$ tons.

Size of fall required for topping-lift $= \sqrt{7 \times 2.75} = 4''.5$ (nearly).

(c) To find the tension on the guys.

The pull on the masthead is the load on the topping-lift (9 tons) plus the tension on that part, BC, of the main purchase fall leading from the boom-end to the masthead.

We have found the tension on the hauling part DE, to be 2.75 tons. The tension on BC is considerably less than this, being reduced by the friction of two intervening sheaves; but for convenience we may neglect this difference, and take 2.75 tons for the tension on BC. This gives, for the pull to be resisted by the guys, $9 + 2.75 = 11.75$ tons. The tension on the guys is found from this as in other examples preceding.

Tension on guys $= 8\frac{1}{2}$ tons.

CHAPTER VIII.

THE COMPASS, LOG AND LEAD.

§ I. THE COMPASS.

The essential part of the compass is a magnetic needle which turns freely on a pivot, and which, if unaffected by local disturbing influences, would point due north and south (magnetic). The local influences which necessarily exist on ship-board and which on steel ships are very large, are more or less fully neutralized by the methods used to "compensate" the compass; and the needle does, in general, point approximately to the magnetic poles.

A recent experience in which a ship was stranded because a small piece of iron had been carelessly left near the compass suggests the necessity for a warning on this point. Iron or steel, even in masses as small as a pocketknife, if brought near the compass, may affect it. Helmsmen and quartermasters should understand this.

Stanchions, railings and other metal fittings near a compass should preferably be of bronze or other non-magnetic substance. If made of iron, they should never be absent, while the compass is in use, from the positions occupied when observations for deviation are made.

Attached to the needle and moving with it is a circular card marked around its circumference with two graduations; one of points and quarter-points, the other of degrees (Plate **56**). The north and south points of the card correspond with the poles of the needle, and the graduation starts from these points. Beginning at north and going around the circle to the right the graduation by half-points is as follows:

North.	East.	South.	West.
N. ½E.	E. ½S.	S. ½W.	W. ½N.
N. by E.	E. by S.	S. by W.	W by N.
N. by E. ½E.	ESE. ½E.	S. by W. ½W.	WNW. ½W.
NNE.	ESE.	SSW.	WNW.
NNE. ½E.	SE. by E. ½E.	SSW. ½W.	NW. by W. ½W.
NE. by N.	SE. by E.	SW. by S.	NW. by W.
NE. ½N.	SE. ½E.	SW. ½S.	NW. ½W.
NE.	SE.	SW.	NW.
NE. ½E.	SE. ½S.	SW. ½W.	NW. ½N.

NE. by E.
NE. by E. ½E.
ENE.
ENE. ½E.
E. by N.
E. ½N.
SE. by S.
SSE. ½E.
SSE.
S. by E. ½E.
S. by E.
S. ½E.
SW. by W.
SW. by W. ½W.
WSW.
WSW. ½W.
W. by S.
W. ½ S.
NW. by N.
NNW. ½W.
NNW.
N. by W. ½W.
N. by W.
N. ½W.

The enumeration of the points and fractional parts of points of the compass in regular sequence is called "Boxing the Compass." It will be noted that the circle (360°) is divided into 32 points, so that one point is equal to 11¼ degrees (11° 15′). Thus a quarter-point is a little less than 3°.

The compass-card with the attached needle (or needles) is floated in a liquid composed of 45% pure alcohol, and 55% distilled water, within a chamber, where it is pivotted upon a jewelled bearing which keeps the card centered and supports a small fraction of its weight. On the inside rim of the card-chamber is a vertical mark known as the "lubber's point," which, in installing the compass, is carefully adjusted in the fore-and-aft line of the ship with reference to the center of the card. In steering, this mark is held in coincidence with the point of the card indicating the course to be steered.

The delicacy with which steamers can be steered by means of the arrangements now employed for the purpose is leading to the disuse of points and quarter-points for compass work and the custom is becoming general of shaping courses and noting bearings, in degrees. The seemingly trifling error that may be involved in attempting to steer by fractions of a point, while of little consequence to a slow vessel in a short run, may be vital to a steamer making four or five hundred miles a day.

In Plate 56 is shown a new compass-card *proposed* (1901) by the Compass Office of the United States Navy Department. It is given here, although it may never be adopted, as indicating the direction of progress in this matter.

The Pelorus or Dumb Compass is a circle marked with the graduation of a compass-card, but without a needle, which may be mounted at any part of the ship for use in taking bearings. A zero-line on this instrument is permanently fixed parallel to the fore-and-aft line of the ship, and a movable sighting bar admits of measuring at any instant the angle between the head-

Plate No. 56.

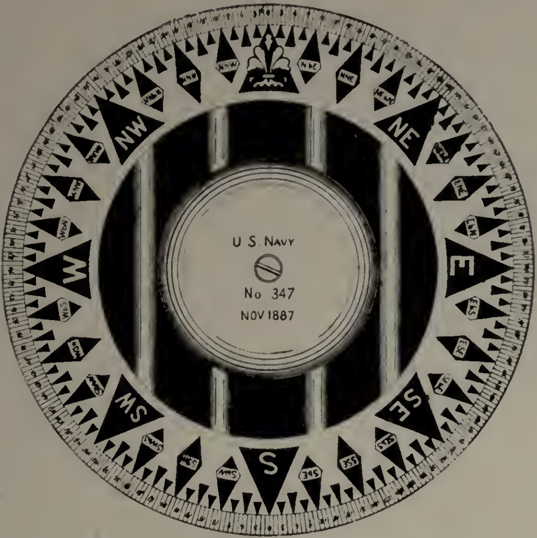


Fig. 1. Compass Card U. S. Navy.

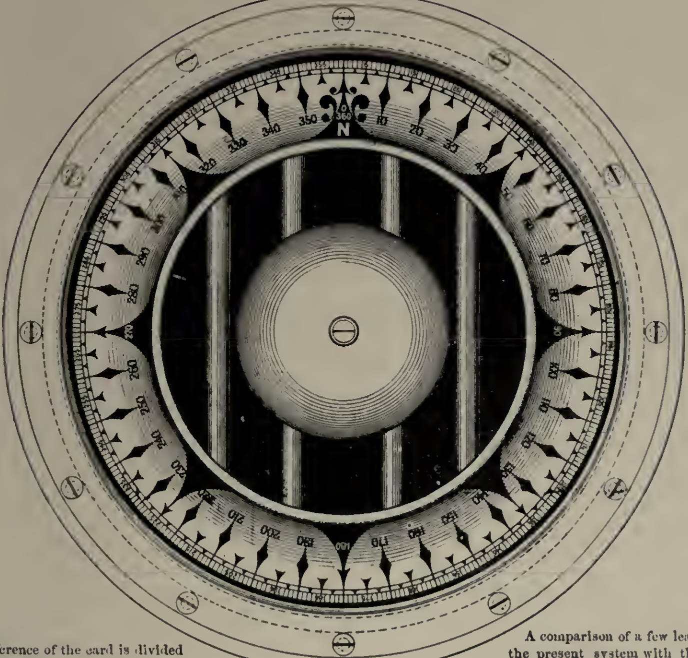


Fig. 2.
Proposed Compass Card.

The circumference of the card is divided into the usual 360 degrees and marked continuously to the right, from 0° at north to 90° at east, 180° at south, 270° at west, and 360 at north.

The card is subdivided as follows:

(*a*) Into divisions of 10 degrees, accentuated by heavy lines on the graduated rim, and by suitable geometric figures on the card, each 10-degrees division of the card being indicated in figures by its appropriate number from 0 or north.

(*b*) Each 10-degrees division of the card is further subdivided into half and quarter divisions and appropriately marked.

(*c*) Every fifth-degree line of the graduated circle between the 10-degree divisions is marked in figures, indicating its appropriate number from 0° or north.

A comparison of a few leading features of the present system with that proposed is given below;

PRESENT CARD.	PROPOSED CARD.
360° = 32 points.	360 = 36 divisions
1 point = 11.25°	1 division = 10°
½ point = 5.625°	½ division = 5°
¼ point = 2.8125°	¼ division = 2.5°
The course is S. 18° or S. by E. ⅝ E.	The course is 162°.
Easterly deviation is *additive* in the NE. and SW. quadrants; subtractive in the SE. and NW. quadrants, to compass course to get magnetic.	*Easterly* deviation is always *additive* to to compass course to get magnetic
Westerly deviation is *subtractive* in NE. and SW. quadrants; additive in SE. and NW. quadrants, to compass course to get magnetic.	*Westerly* deviation is always *subtractive* from compass course to get magnetic.

COMPASS CARDS.

ing of the ship and an object sighted upon. This instrument may therefore be used for determining the compass-bearing of any object, the ship's-head by compass and the bearing of the object by the pelorus being noted simultaneously. Bearings may thus be taken of objects which cannot be seen from the compass. A convenient form of the pelorus is one in which the graduated circle can be turned inside of the fixed rim which carries the zero mark, while the sighting bar turns independently of both. In this form of the instrument, the point of the movable circle corresponding with the compass course of the ship is made to coincide with the zero-mark, so that the compass bearings of objects sighted upon are read off directly, *provided that the ship is exactly on her course at the instant of making the observation.* If it is necessary to make the observation while she is not on the course for which the pelorus is set, the difference must be noted and applied to the bearing observed.

Suppose the pelorus is set for a course *West,* and an observation taken when the ship is actually heading to the *left* of this course:—say W½S. The bearing given by the pelorus must be corrected by ½ point applied to the left (like westerly deviation). If, the pelorus being set as before for West, the ship actually heads to the *right* of this course—say W½N—the correction must be applied to the right, like easterly deviation.

The accuracy of the adjustment of the zero-line in the keel-line of the ship may be determined by setting the circle to the compass course and taking simultaneous bearings with the compass and pelorus of a distant object. If an error is found to exist, it may be noted and applied as a permanent correction to all observations taken with the instrument; or the adjustment may be corrected.

Evidently, if the pelorus is set for the magnetic instead of the compass, course, the bearings observed with it will be magnetic.

§ II. THE LOG.

The old-fashioned chip-log is still found on most ships, although very rarely used. The chip or "ship" is a flat piece of wood, in shape a sector of a circle, weighted with lead along its rounded edge. Three lines, forming a triple span, are led from its corners to a toggle and socket of wood on the log-line. By jamming the toggle into the socket, the span is completed; and if the chip is thrown overboard it will stand vertically in the water, opposing the resistance of its surface to motion through the water, and so long as no considerable pull is put upon the line, may be regarded as affording a fixed point from which to measure the distance run by the ship in a given interval of time. The line is coiled on a reel which turns freely and the line is paid out fast enough to avoid danger of dragging the chip, a certain length of stray line being paid out to get the chip clear of the wake, before the measurement begins. The line is marked and the time noted as described below; and "heaving the log," if carefully done, gives a close approximation to the *momentary* speed of the ship. If the speed varies, repeated observations will give a fair idea of the average speed for an hour or a day.

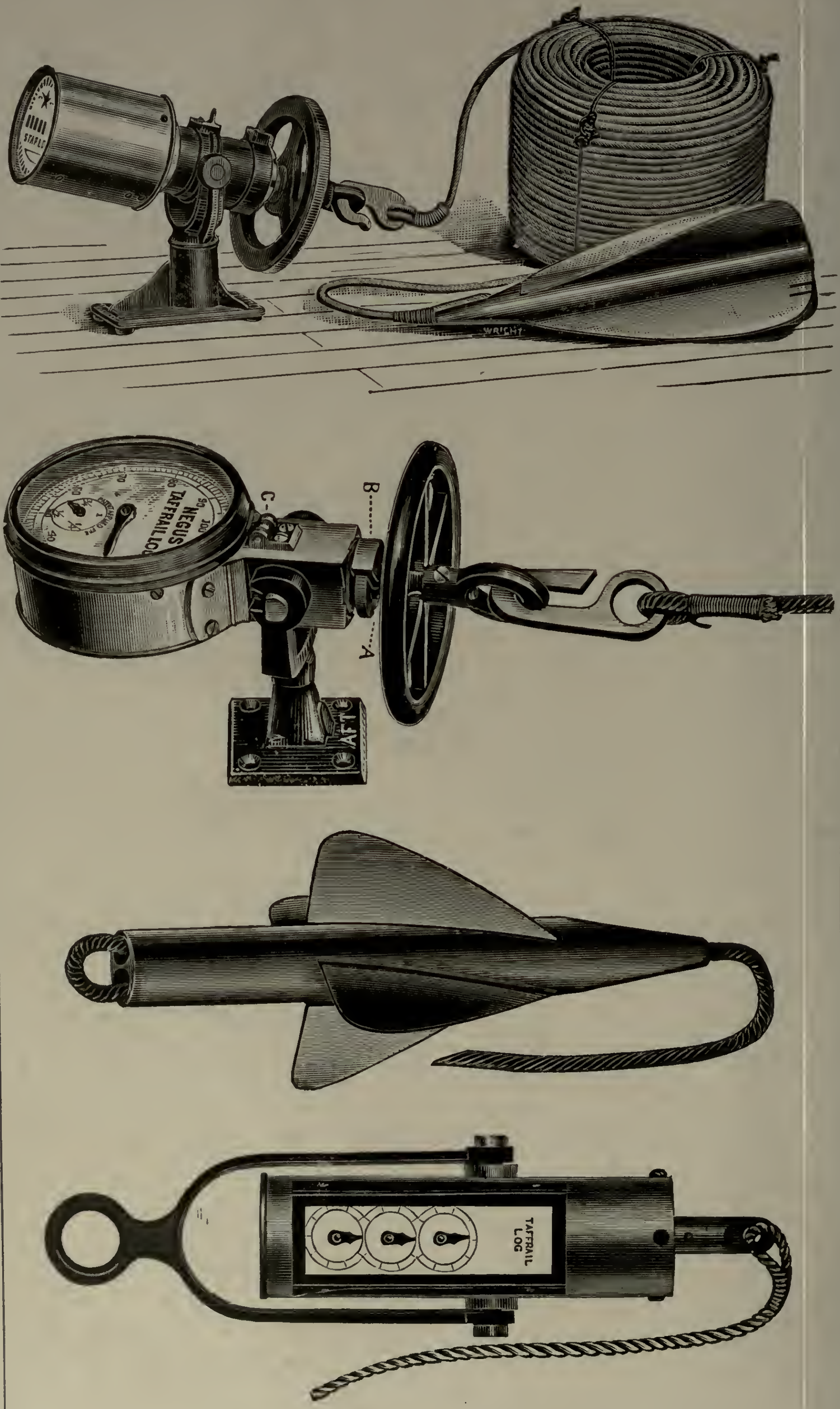
The interval of time is usually noted by a sand-glass marking either 14 or 28 seconds, but a watch may of course be used. The line is marked in "knots" and tenths, a knot as here used being the same part of a nautical mile that 28 seconds is of an hour. If the short glass is used (14 seconds), the speed indicated must be doubled.

To calculate the length of a knot on the log-line, 3600 secs. : 28 secs. :: 6080 feet : 47 feet 3 inches. The marking of the line should be frequently verified, the line being always wet when measured.

For heaving the log, three men are needed; one for the reel, one for the glass, and one, usually an officer or a quartermaster, to attend the line. The reel is held clear of everything and at right angles to the line as the latter runs out. The glass is held ready for turning sharply, care being taken that all the sand is in the lower bulb. The man who is to actually heave the log stands at the taffrail and taking the line in his hand just above the toggle hauls three or four fathoms of slack line from the reel and gathers it in a coil in his hand. When ready, he calls out "*Clear glass?*" and upon receiving the answer "*Clear glass!*" throws the chip and the slack line clear of the dead water under the stern. As the line straightens out, he hauls off more line from the reel with one hand and lets it slip through the other.

As the mark indicating the limit of the "stray" line comes off the reel, he calls out "*Stand by*" and as it leaves his hand,

Plate No. 57.



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PATENT LOGS.

"*Turn!*" He continues to pay out the line, taking care not to leave it too slack, nor yet to drag the chip. The man holding the glass turns it promptly at the order, and watches as the sand runs through. As it approaches the end, he calls "*Look out!*" and as the last of it runs through, "*Up!*" At this the line is stopped and the knots and fraction of a knot that have run out give the speed if the 28-second glass is used, or half the speed with the 14-second glass. A smart jerk of the line pulls out the toggle, allowing the chip to float freely, and the line is hauled in.

PATENT LOGS.

The speed of modern steamers is measured by patent (mechanical) logs of which there are many types in the market. With a few exceptions, these consist of a "rotator," in principle like the propeller of a ship, which is towed through the water and thus made to rotate with a velocity varying directly with the speed, and a series of gears and dials to which the motion of the rotator is transmitted by a cord, the dials registering the distance corresponding to the revolutions of the rotator. In a "taffrail" log, the registering mechanism is on the taffrail and a long line is used between it and the rotator; in a "harpoon" log, the registering mechanism is towed astern with the rotator and must be hauled in for reading. As the record of a patent log is one of distance and not of speed, we must, to find the speed, note the run for a given length of time.

Plate **57** shows several types of patent logs in common use.

A patent log should be given the same care that is accorded to other mechanical devices from which accurate working is expected. It should be oiled daily when in use and kept in a dry place at other times. Logs of the harpoon type should be washed in fresh water before being stowed away.

When a log is first put in service care should be taken to determine accurately its percentage of error. This will be found to vary considerably with the speed, a log which runs correctly at ten knots, being, perhaps, materially in error at fifteen.

The only way to determine the error satisfactorily is by runs of some length between known points where the effects of wind and tide are small. As some effect must always be expected from such causes, a number of runs will be needed to get a reliable error; and for every run that is made, a record should be kept of the comparison between the distance made good by chart and that recorded by the log, a distinguishing number or letter being assigned to each rotator and each register so that their identity may be preserved throughout the record.

If the record shows also the draft of the ship, the revolutions of the engines and the details of wind and sea, it may be of great value.[1]

The length of log-line used has much to do with the working of the log. The proper length to use under ordinary circumstances is that issued with the log by its makers; but it is found that a greater length is needed for a high than for a low speed.

Logs are commonly accompanied by instruments for changing the pitch of the rotator-blades to correct an error in running, but unless the error is very great it is better to leave it and apply the correction found from observation.

The revolutions of the screw of the ship afford a valuable check upon the log and a means of replacing it if necessary, provided the record of revolutions has been kept in connection with the record of the log, and provided also that this same record gives the draft of the ship and the condition of the bottom. Vessels like the trans-Atlantic liners, which make long trips at high speed, sometimes use their patent logs only when nearing land, as it is found that the wear on the bearings of a log at such speeds is very destructive. The fact that these vessels make trip after trip at almost unvarying speed enables them to run with great accuracy by revolutions alone. So, too, boats like the Sound and River steamers of the United States, when running in a fog, depend very largely upon the revolutions and rarely come to grief.

It must be remembered that all the methods which have been described above give the speed through the water, not over the ground. To get the speed over the ground, use is sometimes made of a "ground-log" consisting of a moderately heavy lead on the end of a log-line. The lead is thrown over and allowed to sink to the bottom, after which the line is paid out and the time noted exactly as in the case of the chip-log, care being taken not to drag the lead. This method not only gives the speed over the bottom, but shows the directions of the set.

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[1] The draft of the ship has to do with the revolutions of the screw in relation to speed; not with the performance of the log.

Its availability is confined to rather shallow water and to moderate speeds.

§ III. THE LEAD.

The ordinary method of getting the depth of water is by means of a “lead” and line. A hand-lead, used for moderate depths, may weigh anywhere from 7 to 14 lbs. and a good leadman will get soundings in depths up to 5 fathoms with the ship going 8 knots. If reliable soundings are wanted in depths greater than this, the speed must be reduced or the Sounding-machine used.

The old style of marking the lead-line was as follows:

At 2 fathoms, with 2 strips of leather.
“ 3 “ “ 3 “ “ “
“ 5 “ “ a white rag.
“ 7 “ “ a red rag.
“ 10 “ “ a piece of leather with a hole in it.
“ 13 “ the same as at 3 fathoms.
“ 15 “ “ “ 5 “
“ 17 “ “ “ 7 “
“ 20 “ with 2 knots.
“ 25 “ “ 1 knot.

The above are called the “marks.” The intervening depths are “deeps.”

The old style of reporting the soundings was:

“By the mark, three!”
“By the deep, four!”
“A quarter less, three!”
“And a quarter, four!”
&c., &c.

This method of marking the lead-line and of reporting soundings is antiquated and should be obsolete. A lead-line should have a mark for every fathom and half fathom up to ten fathoms; and for a considerable range—covering the depths that are critical for the ship using it—it should be marked in feet. Thus, if a ship draws 20 feet of water, there should be a mark at every foot between 20 and 30. The soundings should be reported by the leadsman, sharply and clearly, in fathoms and fractions for depths exceeding, say 5 fathoms, and in feet for depths below this.

The lead-line should be of some material that will neither stretch nor shrink excessively as it is alternately wet and dried. An ideal material for this purpose has yet to be proposed. It may be that wire-rope of sufficient flexibility will some time be put on the market.

The lead-lines (wet) should be carefully measured and re-marked each time they are to be used.

As the mark at the water's edge cannot be seen at night, some navigators like to mark their lines in such a way that the depth is indicated by the mark *in the leadsman's hand* when the line is up and down. This calls for a length of stray line equal to the drift from the water's edge to the leadsman's waist; this distance being laid off on the line before beginning to measure for the marks.

For sounding in deep water without a sounding machine, a lead is used weighing from 30 to 100 lbs., with a line correspondingly long and heavy. This is the "deep-sea" lead and line. The line is marked at every fifth fathom.

In sounding, the lead is taken to the forecastle and the line passed forward on the weather side, outside and clear of everything. The men range themselves along the side, each with a little coil of the line in his hand. The line is bent to the lead and when all is ready the engine is stopped, and when the ship has nearly lost her way, the captain-of-the-forecastle calls "Watch-ho, Watch!" and throws the lead over, well clear. Each man along the side holds on until he feels *the weight of the lead*, when he lets the line run through his hand, calling out "Watch-ho, Watch!" If bottom is felt, the depth is noted. The line is snatched in a light block at the taffrail and hauled in.

The lead is "armed" with tallow, filling a hole hollowed out on its lower end, and should bring up a sample of bottom if bottom is reached.

SOUNDING MACHINES.

There are several types of sounding machines, all of which are greatly superior to the clumsy and antiquated deep-sea lead; but the machine of Sir Wm. Thomson is so much more generally used than any other type and has so many points of superiority to all others that it alone will be described here.

Sir William Thomson's Sounding Machine (Plate **58**). This consists of a wooden frame bolted to the deck and carrying a drum upon which are wound several hundred fathoms of galvanized piano wire. The drum is controlled by a brake, the operation of which is explained below. Attached to the end of the wire is a metal cylinder and beyond that and connected with it by a short length of *plaited* rope is a heavy sinker. This rope, carrying the sinker, &c., is connected to a *link* which is permanently attached to the end of the wire.

The metal cylinder carries a slender tube of glass, closed at one end and coated on the inside with a chemical substance which changes color upon actual contact with sea-water. This tube is placed in the metal cylinder with its open end down. As it sinks, the water rises in the tube, the air with which the tube was originally filled being compressed with a force which depends upon the "head" of water acting upon it. As this "head" depends upon the depth, it follows that the compression of the air and hence the height to which the water rises in the tube, becomes a measure of the depth.

With properly coated tubes carefully used, the limit of discoloration is marked by a sharply-defined line, and the depth corresponding to this line is read off by a scale marked in fathoms.

There has lately been introduced as a substitute for the chemically-coated tubes, a tube in which the inside surface of the glass is *ground*. As is well known, ground glass when *wet* shows clear; so that a tube of this kind if perfectly dry in the beginning, should give a clear record of the height to which the water has risen in it. The advantage of these tubes is that they can be used an indefinite number of times if thoroughly dried after each cast. To facilitate drying, a screw-cap is used at the closed end. By removing this, a circulation of air is secured and drying hastened. Except for the difficulty in drying, these tubes are found to work well.

To do away with the inconvenience and expense connected with the use of tubes, Sir William Thomson has invented a "depth-recorder" in which the water-pressure acts upon a piston against the pressure of a spring. The spring and piston are enclosed in a composition cylinder, and the distance by which the spring is compressed is recorded by a marker on the piston stem. This device is convenient and generally accurate, but has not the reliability of the tubes.

This Depth-Recorder is shown in Fig. 2, Plate 58. As the sinker descends, the increasing pressure forces the piston D up into the tube, while the spiral spring pulls the piston back. The amount that the piston is forced up against the action of the spiral spring depends on the depth. To record the depth the marker E is used. As the Recorder goes down the marker is pushed along the piston. When the Recorder is brought up to the surface of the water the piston comes back to its original position, but the marker remains (by friction) at the place on the scale to which it was pushed, and shows the depth to which the Recorder has been. The depth is read off by the cross wire of the marker.

After each cast the nut A should be unscrewed to slacken the valve B, and the Recorder should be turned upside down to empty out any water which may have leaked in. A little water in the upper bottle will not interfere with the accuracy of the indications of the Recorder. It may not be found necessary to empty the bottle every time. Make sure before each cast that the screw A is firmly screwed up and the marker set to zero.

Occasionally a little grease should be pushed up the piston into the tube to keep the leather packing of the piston in good order.

Fig. 1, Plate 58, shows the mechanical details of the sounding machine.

A is the drum carrying the wire and turning freely on the shaft, S. B, B′ are two circular plates carrying bevel-shaped blocks of wood which, when the plates B B′ are drawn together, bind upon the beveled surfaces of the drum and form a friction-brake. B is keyed rigidly to S, but B′ is free. Upon the shaft outside B′ is a nut C, engaging a thread on the shaft. C has an arm D, which projects upward to a clamp, E, attached to the frame of the machine and therefore fixed. Thus so long as D is engaged in E, the nut C cannot turn, and if the handle, H, is turned, the shaft will work through the nut, drawing the friction plates together and binding them upon the drum, or working them apart and allowing the drum to turn freely.

A small cogged-wheel, turning with the reel, engages a set of gear wheels by which the length of line that is out is registered upon a dial on the side of the machine.

In another (later) form of the machine, the nut and arm, C and D, are in one with the plate B′. In other words, the arm D is rigidly attached to B′, the nut C is omitted, and B′ has a screw thread which engages the shaft. It is as if the nut and arm in the type of Plate 58 were bolted to B′. This in no way changes the working of the machine.

The brake being on, the sinker, tube, &c., are lowered over

Plate No. 58.

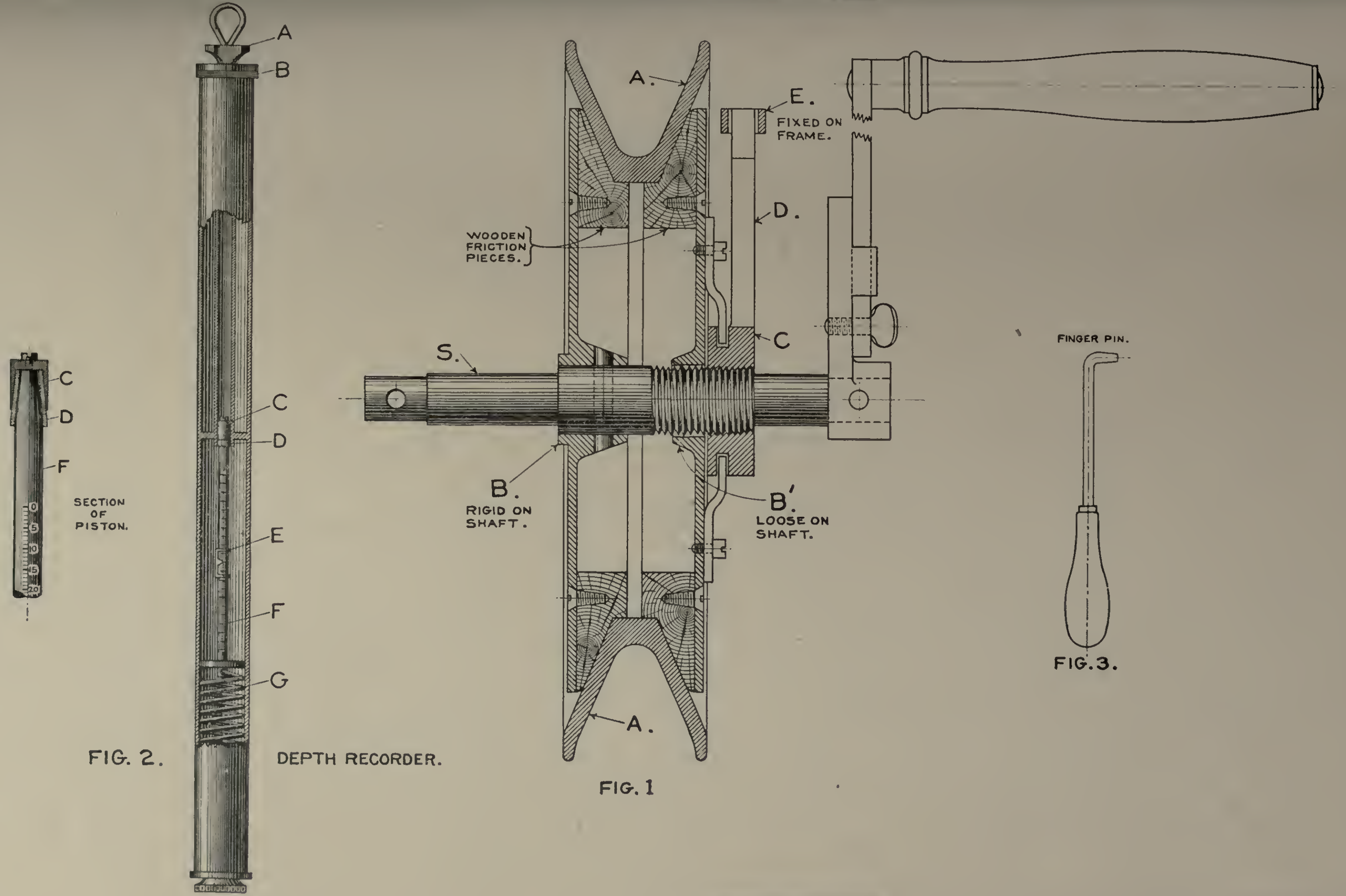

FIG. 2. DEPTH RECORDER.

FIG. 1

FIG. 3.

THOMSONS SOUNDING MACHINE.

the stern and when all is ready the brake is released by a partial turn of the handle. The wire runs out freely until the sinker touches bottom, when the line slacks suddenly. This is a critical instant, as the slacking of the line introduces danger of *kinking*. The brake is instantly thrown on by turning the handle back, and the wire tautens again at once. It is clear that the wire cannot be reeled in unless the nut and arm (C and D) are allowed to turn; for so long as they are held, the shaft in turning will be merely screwing the friction plates (B B′) more tightly upon the drum. To reel in, therefore, we release D by throwing up the hinged clamp E, which allows the reel, friction-plates and nut, to turn together, reeling in the wire.

In handling the apparatus after a cast, care should be taken to keep the glass tube upright. If it is capsized, a little water may run into the upper part of the tube and spoil the record.

Chemically-coated tubes which have been used in shallow water may be used again in water which is known to be *much deeper* than that to which their record corresponds.

As the wire runs out, a little downward pressure is kept upon it with the brass "finger-pin" shown in Fig. 3. This is held by the man at the brake, who "feels" the wire with it, just clear of the reel. As the wire slacks, he bears the bight downward at the same time that he throws on the brake. This helps to prevent kinking on the reel.

In the latest machines, the simple piano wire is replaced by a seven-stranded flexible, galvanized steel wire-rope of about the same diameter as the old style wire ($\frac{7}{100}$ inch diameter). This is much less likely to kink.

The following directions for using the machine are from a pamphlet issued by Messrs. John Bliss & Co., of New York, the American agents of the makers.

1. The work of taking a cast is to be done by two men, under the superintendence of an officer. For brevity, the men will be referred to as brakesman and leadsman. The regular post of the brakesman is at the starboard side of the sounding machine. The regular post of the leadsman is beside the taffrail fair-lead.

2. The men go to their posts, and without further orders the brakesman puts on the two handles and fixes them securely by means of the screws. At the same time the leadsman sees that the lead is properly armed, and takes it along to the fair-lead. The officer examines the tube and places it in the guard-cylinder.

3. The brakesman standing on the starboard side of the machine sees

that the arm D is prevented from turning by means of the catch. He then takes hold of the handle and puts the brake on by turning the handle in the direction for winding in the wire. When the brake is sufficiently tightened the brakesman calls out "brake on." The leadsman then lets down the sinker without a jerk till it hangs upon the rope. The brakesman then, holding the handle in one hand, releases the arm D and pays out by turning the handle until the link (connecting the plaited rope to the wire) has passed over the fair-lead. The leadsman then calls out "on brake," at which order, the brakesman engages the arm D in the catch E. The brakesman then reports "brake on," and the leadsman allows the sinker to hang free.

4. The brakesman now, having seen that the index of the counter is at zero, takes the brass finger-pin,[1] and holding it lightly by its handle, presses it against the wire and waits for the officer to give the order "let go."

5. The brakesman instantly turns his handle in the direction for paying out until the drum with wire rotates freely. While the wire is running out he holds the handle in one hand and the finger-pin pressing against the wire in the other hand. The brakesman watches the counter, and if the bottom has not been reached before coming to 250, *he commences to apply the brake as soon as he sees the index of the counter at 250, so as to stop before 300 is reached.* As soon as the brakesman feels the wire slacken he at once begins turning the handle in the direction for hauling in until the brake is tightened up and the egress of the wire stopped. He then releases the arm D and commences to wind in.

6. The leadsman winds with his left hand and guides the wire to the drum with a piece of waste canvas in his right hand. The brakesman, winding with both hands, watches the counter from time to time during the winding in, and when the link is five fathoms from the fair-lead, he calls out "hand the lead."

NOTE.—When the speed exceeds ten knots it is desirable to have another man to help in the winding. He is to stand looking aft, and to work with both his hands on the port handle, the leadsman working on the same handle with his left hand.

7. The leadsman instantly leaves the machine, goes to the taffrail, and steadies the link and cord by his hand as they come up, and guides the link over the fair-lead; while the brakesman continues slowly winding in until the link reaches the wire drum; and placing it properly on the wire drum he winds in one turn more; then, taking care that the link is a little above the middle of the after side of the drum, so that its weight may help to keep the wire stretched, he puts on the brake. Meantime the leadsman hauls by hand on the sinker. The leadsman then takes the lead on board, shows the tube to the officer, examines the arming for specimen of bottom, shows it to the officer, and prepares the arming for a fresh cast, and then goes forward to the machine and stands by for another sounding.

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[1] The brass finger-pin is supplied with the machine, but if it should be missing or lost a piece of hard wood will do to press on the wire while the sinker is going to the bottom.

8. The reading on the counter shows approximately the number of fathoms of wire run out. This may be something more than twice the depth for speeds under 11 knots; or it may be almost as much as three and a half times the depth if the speed be 15 or 16 knots. The proportion of wire to depth differs not only with the speed of the ship, but also with the roughness of the sea and with the depth itself.

CAUTIONS AND EXPLANATIONS.

9. The wire will break *at a kink* under a very moderate pull or a very slight jerk. Without a kink, and with proper care, the wire can scarcely be broken in practice with the machine. No wire should ever be lost in service, unless by some extremely rare accident, not foreseen, and therefore not provided against.

10. Absolute security against kinks would be had if the wire could be prevented from ever slacking. It does slacken somewhat the moment the lead touches the bottom, but not to a dangerous degree if the ship is going at anything more than 5 knots, and if the brake is instantly applied, when, by the wire's yielding to the brass pin, the commencement of slacking is shown. The brake should be instantly applied, so as to slow the motion of the wheel, but not with force enough to stop the wheel suddenly. There is much more danger of losing the wire through a kink in taking an up-and-down cast than in a flying cast with the ship running at 12 or 14 knots. *Whenever a cast is taken at any speed less than 5 knots, it is advisable to manage the brake so as to moderate the speed of egress according to judgment, letting the wheel run round at something like three turns per second.* If the ship's speed is more than 5 knots, observe all the rules laid down in the instruction preceding.

CHAPTER IX.

BOATS.

§I.

Boats designed to be carried on shipboard are subject to many requirements connected with lowering, hoisting and stowing, which define their characteristics within narrow limits, especially as regards their size and weight. The boats of a merchant vessel are intended almost exclusively for saving life under circumstances of emergency, when they must be handled by a small number of men and usually under conditions of more than ordinary difficulty. It is therefore as important for them to be light and handy as to be roomy and seaworthy. The boats of men-of-war are used for a great variety of purposes, and in design are usually a compromise between conflicting demands.

In considering the type of boat most desirable for ship's use, a distinction should be made between the general service of the ship, whatever that may be, and the specific object of saving life in the case of a man overboard or of a call for assistance from another vessel in distress. For these last-mentioned objects and other similar ones, calling for the sudden lowering of a single boat, a type is needed which shall be exceptionally light, handy, and, above all, buoyant and seaworthy. It will be generally admitted that the type which best meets these requirements is the "whale-boat" of the New England whaling ships, which is quite a different thing from the boat commonly known under the name of a "whaler" in other ships. The true whale-boat has moderate beam, a long rather flat floor, an easy turn to the bilge, a very bold sheer and *no deadwood* either forward or aft. This absence of deadwood results in a sharp rake to the stem and stern posts, which round boldly in to meet the shallow keel. The lines are considerably fuller at the bow than at the stern, and this leanness of the after-body is one of the most characteristic features of the type.

Fig. 1, Plate **59**, is taken from an actual New Bedford whale-boat, and is believed to be the first authentic drawing of such a

Plate No. 59.

Fig. 1

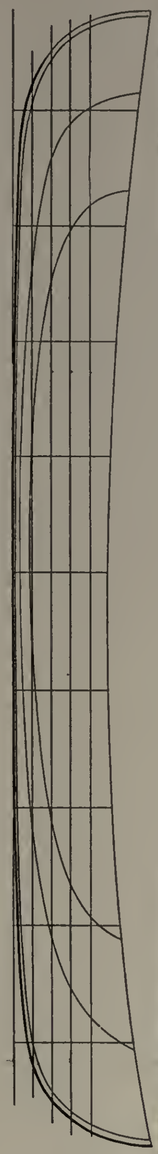


Fig. 2

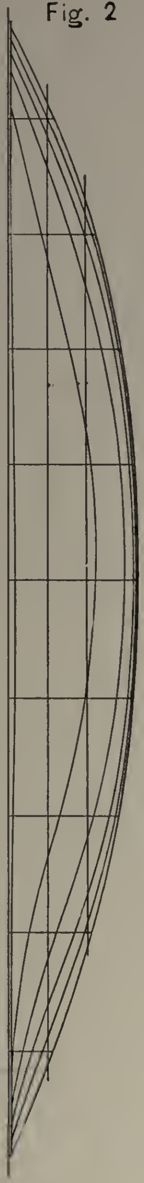
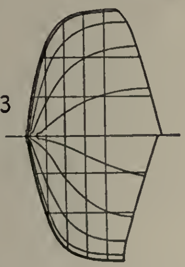


Fig. 3



Lines of a New Bedford "Whaleboat."
Sheer, Half-Breadth and Body Plan.

Fig. 4

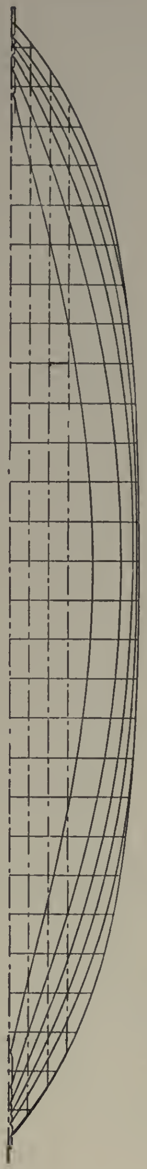


Fig. 5

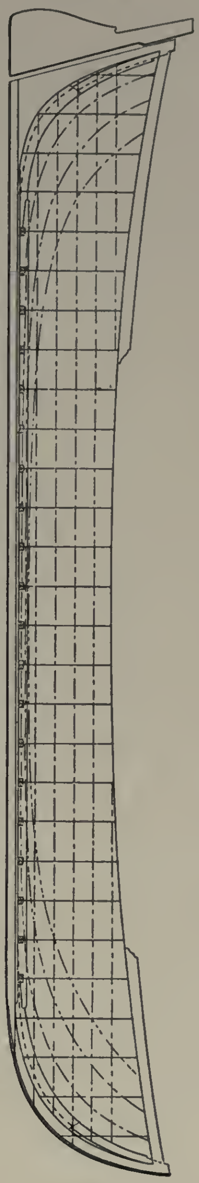
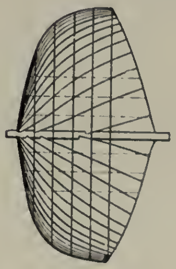


Fig. 6



29 Ft. Whaleboat
Sheer, Half-Breadth and
Body Plan.

WHALEBOATS

boat ever published. The planking of these boats is never more than one-half inch in thickness; and the seams, instead of being calked, are covered by a light batten run along them on the inside. The timbers, knees, stem and stern post, etc., are also very light; indeed, every effort is made to gain buoyancy by saving weight.

Of late years whale-boats have been built for sailing rather than for rowing, and as a consequence the center-board has come into use and has necessitated some changes in design, which, however, do not essentially modify the description given above.

The true whale-boat is single-banked and designed to steer by an oar, though a rudder is fitted and works fairly well in smooth water. It should always be fitted to the curved stern post—*not to a straight post made by filling in with deadwood*—as this filling-in destroys one of the most important features of the type. The lightness of these boats, coupled with their form, makes them so buoyant that they ride over the waves where other boats cut through. The comparative flatness of the floor, the shallowness of the keel, and the absence of deadwood, make them very quick in turning, especially when steering by an oar; and this characteristic, added to their remarkable buoyancy, fits them peculiarly for use in a surf. They sail badly on a wind (unless fitted with a center-board), the lack of hold upon the water resulting in excessive leeway; but they do well off the wind and run well before a sea, and they can be rowed against a sea in which a deep cutter would be altogether helpless.

The crutch for the steering oar, which in navy boats is shipped at the very stern, is, in whaling, carried on a bumpkin projecting from the quarter of the boat. This brings it to one side of the man who handles it, and gives him much freer control than he could otherwise have.

Fig. 5, Plate **59**, shows the whale-boat of the U. S. Navy.

The whale-boat is not well fitted for the general purposes of a man-of-war, but could be perfectly adapted to the needs of the merchant service by certain modifications in the direction of carrying capacity. The boats commonly used by merchant vessels are "double-enders," and to this extent resemble whale-boats, but beyond this they have little in common with the type that has been described above, and certainly they have few of its admirable characteristics, being apparently designed in many cases merely to meet the requirements of the laws to which they must conform.

The English law on this subject recognizes the following types of boats and specifies how many shall be carried by vessels under various circumstances.

"Section (A). A life boat of whale-boat form having one (1) cubic foot of air casing for every ten (10) feet of capacity."

"Section (B). A life boat of whale-boat form in which half of the buoyancy must be provided on the outside of the boat. Inside and outside buoyancy together to be equal to the buoyancy of the (A) boats."

"Section (C). A life boat having only half the total buoyancy of boats (A) and (B). Of this amount, half must be fixed on the outside of the boat."

"Section (D). A properly constructed boat of wood or metal."

"Section (E). A boat of approved construction, form and material, and may be collapsible."

The buoyancy referred to as on the outside of the boat is usually given by cork arranged in the form of a fender around the gunwale outside. The inside buoyancy is given by airtight tanks.

Collapsible boats, of which the best known type is the *Berthon*, are carried by many small ships, but are not often adopted for large ones. A type of "semi-collapsible" boat is carried by many steamers and has much to recommend it. It has a raft bottom, lightly but strongly built, with water-tight compartments in which provisions may be stowed.

There are many situations at sea in which a small, light boat like the "dory" of the New England fishing banks would be extremely useful (Plate **61**, Fig. 1). These boats may be launched in a moment by one or two men and when properly handled are wonderfully good sea boats. Several of them can be stowed in a "nest," one within the other, and occupy very little room.

Metallic boats are preferable to wooden ones when they are to be carried in such positions that they are of necessity exposed to excessive heat and moisture and when they are not to be often used. If subject to the sort of treatment that the boats of a man-of-war receive they would quickly be battered out of shape, and sooner or later punctured, when the problem of repair on shipboard would become a difficult one.

Life-rafts of the balsa or catamaran type are very useful and it is to be regretted that all ships are not required to carry a num-

Plate No. 60.

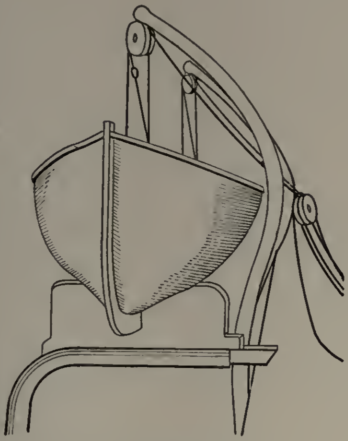


Fig. 1 Mallory Davits.
Boat Inboard, Resting on Chock.

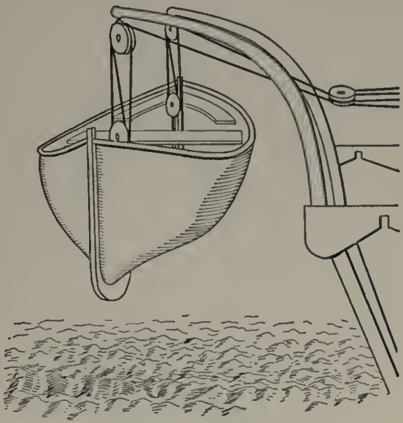
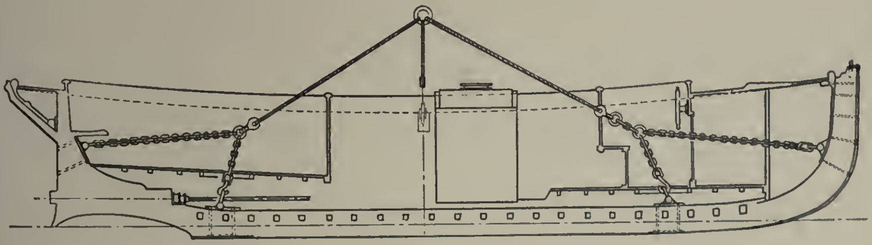


Fig. 2 Mallory Davits.
Boat Ready to Lower.



Slings for Hoisting a Heavy Boat.
(Steam Launch, United States Navy).
Fig. 3

HOISTING AND STOWING BOATS.

ber of them. They can be transported easily from one part of the ship to another, and can be launched overboard at any point and by anybody. They give a hope of saving life under conditions such that a boat would be altogether useless.

The Build of Boats.—There are in common use three systems of building for boats—the Carvel, Clinker (or Clincher) and Diagonal.

In Carvel building (Figs. 2 and 3, Plate **61**), the planks lie alongside each other without overlapping, the seams being calked and payed. Where the build is too light to admit of calking, a narrow batten or riband is run along the seams inside, the calking being in this case limited to the garboard seams and the butting ends of the planks.

Where heavy boats are built on this system, a second layer of planking is sometimes used inside the frames.

In Clinker building (Fig. 2, Plate **61**), the planks overlap at their edges like the clapboarding on a house, and are fastened to each other as well as to the frames. As the planks thus support each other, this system has greater strength for a given weight than Carvel building and the frames can be placed farther apart. On the other hand, the planks are liable to split along the line of fastenings, and repairs called for by this or other injuries to the boat are made with some difficulty because of the necessity of removing several planks to repair one. The seams are not calked, the swelling of the planks causing them to bind tightly upon each other. To keep them tight, the boat should be put in the water frequently, or, if that is impracticable, well wetted with a hose from time to time.

In Diagonal building, the planks run diagonally at an angle of 45° from the keel to the gunwale and two thicknesses of planking are used, at right angles to each other. No frames are needed. This is a strong system of building, but necessarily a heavy one. As a rule it is used only for launches and other large boats carrying heavy weights.

The Carvel and Diagonal systems are sometimes combined, two layers of planking being used, one carvel laid, the other diagonal.

Fig. 3, Plate **61**, shows the details of the Carvel-built boat.

Classification of Boats.—Boats are single- or double-banked, according as they carry one or two oarsmen on each thwart.

The boats of a man-of-war are classified as follows:

Launches.—These are large, heavy boats of great beam, flat floor and rather shallow draft, designed for carrying stores and men, and fitted to mount one or more light guns.

Cutters.—These are smaller than the launches, designed for the same general purpose, but used, in addition, for the miscellaneous work of the ship. They are narrower than launches and of deeper draft. The "pinnace" of the English Navy is a large cutter.

Whalers.—Double-ended boats resembling more or less closely the whale-boat already described.

They are used, like lighter cutters, for the miscellaneous service of the ship, but are rather more convenient than cutters for passenger boats, and much more convenient for life-boats.

Galleys and Gigs.—The galley of the English Navy is a long, narrow, rather deep, single-banked boat with a square stern. This type of boat was formerly used almost exclusively in all navies for the gigs of commanding officers, but is being displaced by whale-boat gigs, which are in all ways to be preferred.

It should be noted that the term "galley" describes the form of the boat, while "gig" has to do with the purpose for which it is used.

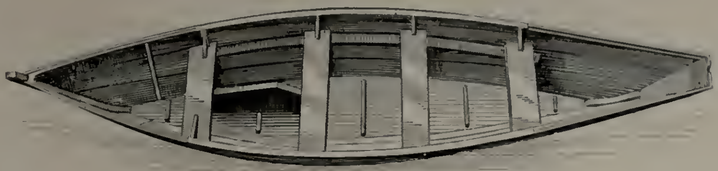
Dinghys.—These are small handy boats, with square sterns, pulling usually four oars, used for transporting marketing, servants, etc.

Jolly-boats, Yawls, etc., are small, lightly-built boats pulling two or four oars (usually double-sculls) for general utility.

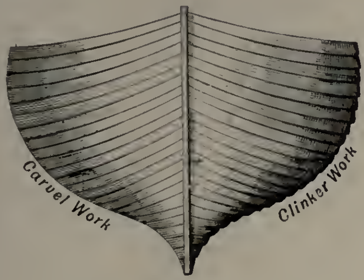
A **Barge** is the personal boat of a flag officer. It is like a large cutter, but with rather more beam, has a round or square stern, is double-banked, and usually pulls either twelve or fourteen oars.

Steam-launches, Steam-pinnaces, Steam-cutters, and **Steam-whalers** are boats having the general characteristics already described, but fitted to run by steam, and, naturally, more strongly and heavily built.

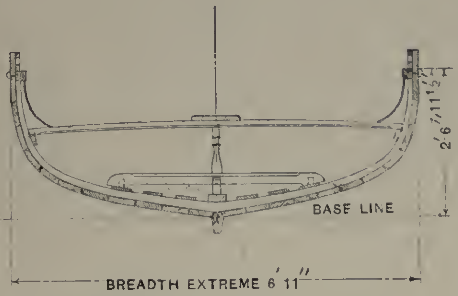
Plate No. 61.



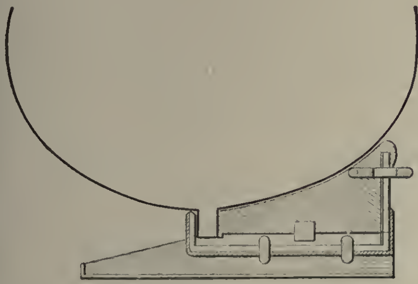
New England Dory
Fig 1



Carvel and Clinker Work
Fig. 2



Section of a U. S. Navy Cutter
(Carvel-built)
Fig. 3



Stowing Boats
("Kaiser Wilhelm der Grosse")
Fig. 4

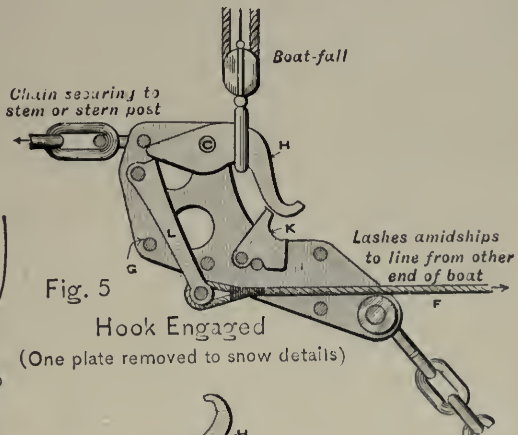

Boat-fall
Chain securing to stem or stern post
H
K
L
G
Lashes amidships to line from other end of boat
F
Chain securing to keel

Fig. 5
Hook Engaged
(One plate removed to show details)

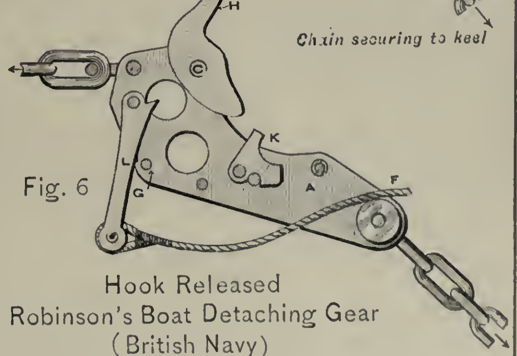


Fig. 6
Hook Released
Robinson's Boat Detaching Gear
(British Navy)

BOATS AND THEIR FITTINGS.

§II. THE STOWAGE AND HANDLING OF BOATS.

The arrangements for carrying and handling boats on shipboard as they exist at present are in most instances far from satisfactory. In the case of men-of-war there is perhaps little that can be done to improve matters (except in the type of davit used) as the exigencies connected with the placing and using of the battery to the best advantage establish limitations, in connection with which everything else is of minor importance. Men-of-war usually carry a few boats at davits along the side from the waist to the quarter, and others on an elevated deck or "gallows frame" from which they are either lifted by a heavy boom and swung over the side, or run out by means of traveling cradles to davits, where they are hooked on, hoisted, swung out and lowered. Whichever method is used, the process of getting them out is necessarily slow, and with the average man-of-war not even the most perfect drill and discipline could give much hope of saving life by these boats in case of sudden disaster. As life-saving in a man-of-war is necessarily secondary to many other considerations, this matter is not as important as in merchant steamers, with hundreds, or it may be thousands, of passengers and with small crews, often very inadequately drilled.

Many seamen contend that boats should be carried hanging at their davits and *swung out*, under all ordinary circumstances, and rigged in only very bad weather. The fact that all well-organized steamers habitually carry one or two boats in this way is sufficient evidence that it is not impracticable, although the wear and tear upon blocks and falls would doubtless entail considerable expense.

Captain Mills of the steamship Westernland writes to the author in reply to the question whether he considers it practicable to carry the boats of an ocean steamer swung out. "Yes, I have carried this ship's largest boats (548 cubic feet) swung out in several heavy gales and I think they are safer there than in chocks unless the vessel is very low in the water."

It should be stated that a majority of the officers to whom this question was put replied that they considered it impracticable to carry the boats in this way.

Whatever may be thought of the feasibility of this plan in general, there can be no question that all the boats of a passenger steamer should be cleared away and kept ready for lowering at certain times of exceptional danger; as, for example, when running through crowded waters in a fog.

As a general thing, the boats of merchant steamers are stowed in cradles on deck, where they are lashed and covered. Iron davits, curved and turning in sockets bolted to the side of the ship, are swung in to plumb the bow and stern of the boat, where the tackles from the davit-heads hook to ring-bolts. To get them out, the covers and lashings must be cast off, the boats lifted sufficiently to clear the cradles, and the davits swung out, one at a time, throwing the boat clear of the side and into position for lowering. This is not a difficult operation, nor necessarily a long one, if the boats are in good condition, the officers and crew cool and well disciplined, and the ship on an even keel. But such conditions as these are altogether unusual. As a rule, when the boats are needed in a hurry, neither the force nor the skill is available for lifting and swinging them out; and often the ship has a heavy list, making the difficulty of swinging out almost insurmountable.

In all cases where boats are stowed inboard the arrangements should be such that the boats need not be lifted to free them of the chocks. Where the davits are of the long curved type common on merchant steamers, this may sometimes be arranged by lashing the boats down, the lashings being fitted with slip-hooks, and then hauling taut the falls and belaying them with considerable tension. When the slip-hooks are knocked adrift, the tension on the falls, *coupled with the spring of the davits*, causes the boat to spring up clear of the chocks, which, if properly fitted, may then be turned down or otherwise cleared away.

In the plan shown in Fig. 4, Plate **61**, chocks are used on the inboard side of the boat only; an iron rod, running along the chock athwartships and bent up at its outer end around the keel, serving to hold the boat on the side to seaward. By knocking the lashings adrift and turning down this rod, the boat is released in an instant.

The boat cover should be put on and secured in a way which will admit of casting it quickly adrift. The arrangement should be such that the cutting of a single line will release all the stops.

The boat should, if possible, be so placed under the davits that one end is ready to swing outboard at once, doing away with the necessity for launching bodily forward or aft.

Fig. 1, Plate **60**, shows a form of davit which does away with the necessity of swinging out, the boat being habitually stowed outside the davits, although resting in chocks.

The guys and span should be fitted to the *top* of the davits and turn freely there. If hooked on at the sides, as they sometimes are, they foul when the davit swings.

The falls are handier when coiled outside the boat, though this does not look as neat as to coil them inside. As already explained, they are kept taut enough to lift the boat slightly when the lashings are knocked clear, as well as to hold it if the cradles are washed away by a sea. They must be belayed to a cleat on the davits in order that the latter may swing freely, and it is important to make sure that they are belayed properly for lowering.

The cleats should stand out from the davits sufficiently to admit of lowering without jamming. This is a small point, but one which may be of vital importance.

Unless the boats and all their fittings are inspected frequently and thoroughly, there will be trouble when they are wanted. The custom in well-ordered vessels is to overhaul everything when preparing for sea and at regular and frequent intervals afterward; examining and oiling all parts of the disengaging gear and all blocks, swivels, etc. The boats are swung out before starting on a trip, and, if possible, lowered and hoisted to make sure that everything is in good working order. All the fittings and equipments of the boats (see list below) are inspected, water-breakers and bread-tins emptied, cleaned and refilled. Both at sea and in port, the boats are wetted frequently to keep the seams tight, but are never allowed to lie for long periods of time with water in them, as this rots the wood and rusts the fittings.

Plugs are habitually kept out, but especial care must be taken to insure that they are secured in such a way that they cannot be lost. At least two plugs should be provided for each hole and made fast in the boat by good lanyards.

Several new devices for handling boats have been proposed quite lately and tested with promising results. There is good reason to hope that before many years great improvements in this line will be effected.

EQUIPMENT OF BOATS.

In preparing a list of articles for the proper equipment of a boat, it is necessary to consider the service for which the boat may be needed. One which is to be carried at the davits ready for lowering at a moment's notice to pick up a man overboard calls for a very different outfit from one which is never to be used except in case of disaster to the ship.

The following are common to all boats:

A rudder and tiller, each fitted with a light lanyard.

A plug, secured to the keelson by a good lanyard.

A set of rowlocks, with two or more spare.

A set of oars, with two spare.

Two boat-hooks.

A bucket for bailing and general utility.

A breaker containing fresh water sufficient to last the proper crew of the boat at least three days.

A lantern, filled, trimmed, and ready for lighting, with a box of safety matches well wrapped in oiled silk.

Painters, bow and stern.

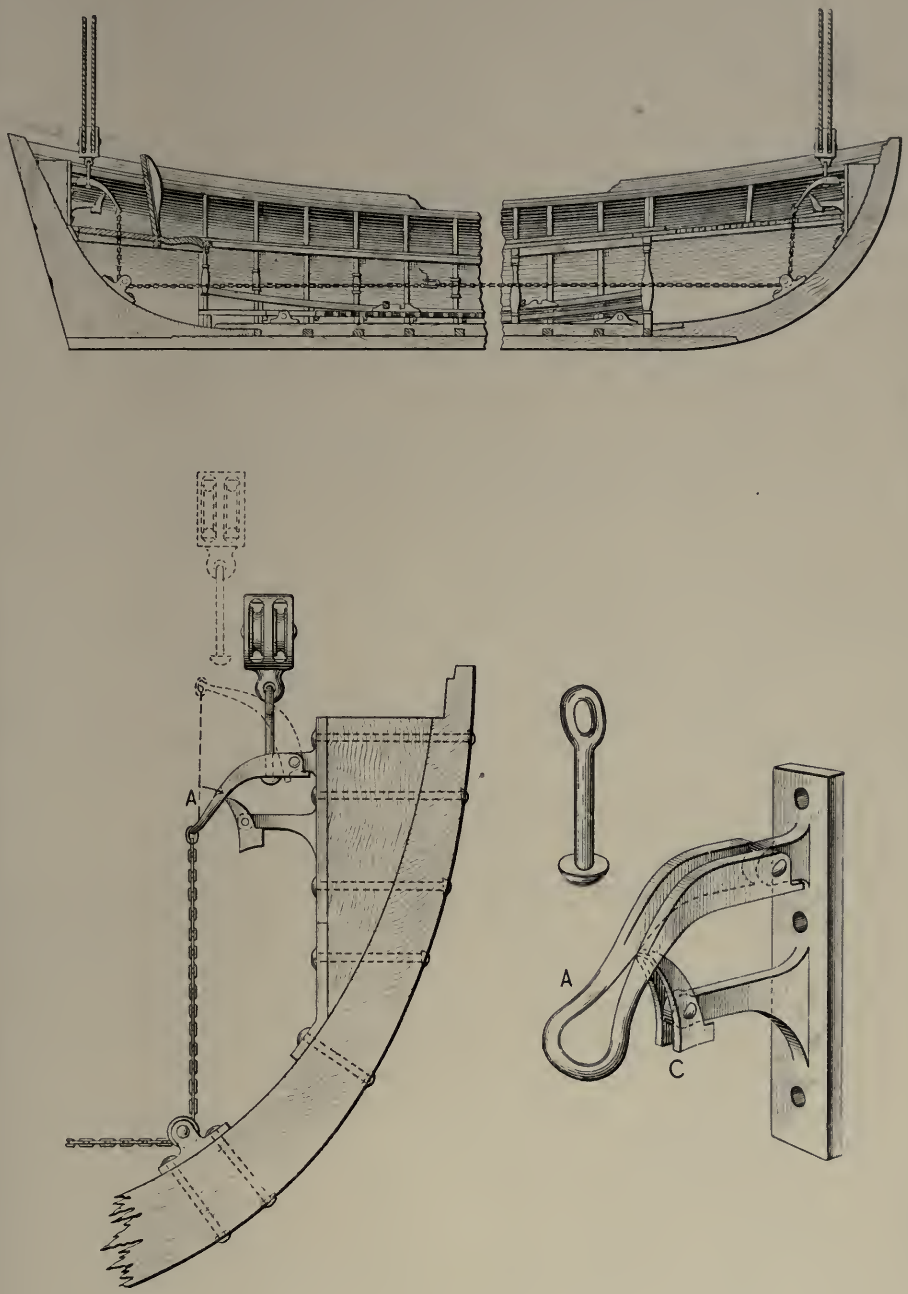
Fireworks of some satisfactory kind for attracting attention.

A light like the "Holmes," which ignites on contact with water, has much to recommend it.

The English Board of Trade Rules require, in addition to the above, a set of sails and spars, a compass, a sea-anchor, two hatchets, a gallon of oil and a vessel to distribute oil. The insistence upon sails and spars clearly contemplates the possibility of a trip of some length after leaving the ship. No doubt such trips have been made by boats under sail, but in a great majority of cases the space occupied by the sails and spars could be utilized to better advantage for passengers, even if the boat were reduced to waiting helplessly for a passing vessel. A sea-anchor would be useful in a gale, but need only be carried if sails are omitted, as these two would never be wanted at the same time and the sails and spars lashed together (with sails loosed) make a perfectly efficient sea-anchor.

Probably no one would think of putting sails and spars into a boat intended for picking up a man overboard. Such a boat should be as light as practicable and should afford all possible freedom for handling the oars. The articles named in the first of the above lists are needed in such a boat—fireworks being perhaps the one upon which most stress should be placed, as it is the one most likely to be omitted. Water and provisions in quantity sufficient to last for several days should be kept in all boats at all times.

Plate No. 62.



WOOD'S DETACHING APPARATUS.

DETACHING APPARATUS.

Whether or not a special detaching apparatus is an improvement on the old style of links and hooks is a question upon which seamen are far from agreeing. There is substantial agreement that a "thoroughly reliable" apparatus is desirable, but a certain lack of confidence is felt in the devices now on the market.

The most important requisite for a detaching apparatus is that it should be incapable of dropping one end of the boat without the other. Whether the release should be controlled by some one in the boat or by an officer on the ship is a disputed point, but it may be noted that nearly if not quite all of the devices in current use are worked in the boat, which would seem to indicate that practical men prefer this system.

There has been much discussion as to whether the release should be capable of acting before the boat is "waterborne"; but this point, too, seems to be settled practically by the fact that, of the devices in common use, nearly all admit of dropping the boat before it touches the water.

It is very desirable to have a system which provides not only for detaching the boat, but for *lowering* the two ends together. This is one of the chief advantages of Clifford's device, described below.

An effort is sometimes made to secure the same result by reeving both falls in one, a single block at each davit head giving a lead from one fall to the other. With frictionless blocks this would doubtless accomplish the purpose desired, but in practice it is usually a failure unless the boat is very heavy, and fairly well balanced as to weight.

Still another point of importance is convenience in hooking on in a seaway, but this is less vital than safety in lowering and getting clear.

Several of the best known types of detaching gear are described below.

Robinson's Detaching Gear. (Plate **61.**)

The hooks of this gear work between two plates which constitute a frame for the gear and which are attached to the boat by two chains as shown in Fig. 5, where one plate is removed to show the details of the gear.

The remaining plate is a duplicate of A.

H is a hook, pivoted at C and engaging a link on the lower block of the boat fall. H is prevented from turning by its bearing on the short arm of the lever L, which in turn is held by the wire lanyard F, which must be *released* to detach the boat. The tumbler K prevents accidental unhooking.

A safety-pin, G, prevents the turning of the lever if the lanyard is accidentally let go. This safety-pin should be in place at all times except when ready for lowering the boat.

To detach, the safety-pins are withdrawn and the lanyard attended. At the proper moment, the lanyard is released and the boat is freed, whether waterborne or not.

For hooking on, the safety-pins must be in place.

Wood's Detaching Gear. (Plate **62.**)

The boat hangs by a link of peculiar shape, hinged at one end upon a casting firmly bolted to some rigid part of the boat. The other end of the link is held down by a chain leading over a roller and thence forward along the inner keel to a slip-hook, by means of which it is connected with the corresponding chain from the other end of the boat. A shoulder at the hinge of the link prevents it from turning down too far. Hanging from the lower block of the boat fall is a toggle with an enlarged head at the end. To hook on, the head of this toggle is inserted in the enlarged part of the link and allowed to slip up into the narrow part toward the hinge. It is prevented from slipping back, no matter how much the boat may thrash about, by a tumbler, which turns freely to let the toggle slip in, but is held, by its bearing against the link, from turning in the other direction. To detach, the slip-hook connecting the two chains and holding the links down, is released, and both links turn freely, allowing the toggles to slip through the enlarged ends of the links.

Where blocks are not supplied fitted with toggles for use with this apparatus, toggles may be made and attached to the blocks.

It is immaterial for the working of this apparatus whether the boat is waterborne or not, as the slightest pull on the falls after the chain is released will unhook them.

To use this attachment for unhooking in the ordinary way (without releasing the chain), it is only necessary to turn back

Plate No. 63.

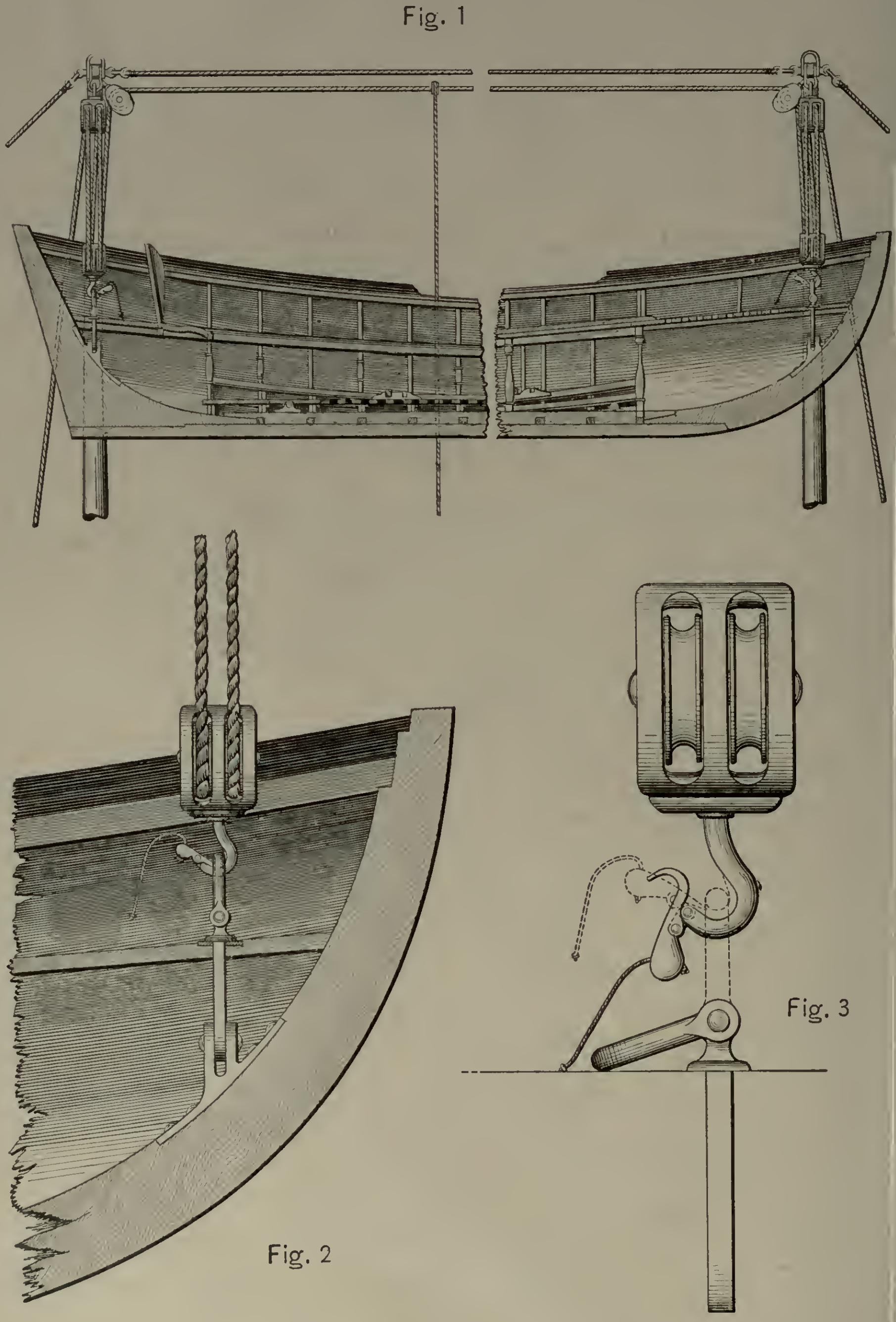


Fig. 1

Fig. 2

Fig. 3

AUTOMATIC RELEASING HOOKS.

the tumblers by hand, when the toggles may be slipped down to the enlarged part of the link and so freed.

Automatic Releasing Hooks.

Plate **63** shows a form of releasing hook used in the United States Navy. The hook is in two parts, hinged one upon the other with a double joint. The outer part, which forms the point of the hook, is weighted, and falls down when free to do so, disengaging itself from the link in the boat. The release can act only when the boat is waterborne, as the weight of the boat at other times holds up the other part of the hook. For hooking on, a lanyard attached to the point of the hook is rove through the link in the boat, and the hook is pulled through with this and held up in place until jammed by the weight of the boat.

To insure detaching both ends together, the falls are rove of a single length of rope "on the bight." This being the case, as soon as one hook is disengaged the slack is communicated to the other fall and the second hook released also.

The following directions are from a pamphlet issued by the manufacturers of the device:

> **Mode of Reeving the Falls.**—"If the boat is always carried outboard two single swivel blocks should be seized to the cranes about six inches from the upper blocks at the davit heads. The falls must be in one piece, and should be passed through the two single blocks until the same amount of rope is on each side of the davits, then go to the lower and upper blocks, the same as if reeving off a set of davit falls ordinarily, with this exception—bring the hauling part of the forward fall through the forward sheave of the upper forward block, and the hauling part of the after fall through the after sheave of the after upper block. A piece of 'ratlin stuff' spliced around a bull's-eye and rove in the bight of the falls between the two single blocks, so that it will play freely between them, will enable one to secure the bight and control it if necessary, and by setting a strain on it hoist the hooks clear of the boat when they are detached. By keeping a strain on the bight and the falls, after the boat is hooked on, takes up whatever slack there is when the sea lifts the boat. By stopping the bight between the two single blocks, the falls will act independently of each other and are similar to an ordinary set of davit falls.
>
> "If the boat is carried inboard, the single blocks should be made fast around the necks of the upper blocks with a grommet strap, so as to allow them to swing in and out with the cranes; by doing this the bight of the falls will swing clear of the upper blocks."

Clifford's Lowering and Detaching Gear.

Many seamen whose experience goes back to the days when "Clifford's" gear was in use, consider that system superior to all others, as in theory it doubtless is. It is shown in Plate **64**. Although not now used to any important extent, it is given here as illustrating some of the most important principles involved in the problem of lowering boats. To lower a boat on an even keel and to let it go by the unreeving of a single pendant at each end is a method of beautiful simplicity, and it would seem worth while to attempt the perfecting of this apparatus by overcoming the difficulties which have led to its practical abandonment. These difficulties seem to be two in number: 1st, The single pendants by which the boat hangs cannot be made strong enough for a heavy boat without being made too large for convenience, and 2d, the pendants swell in damp weather, and in cold weather become stiff and hard, so that they cannot be trusted to unreeve.

The boat is held by two pendants, rove as shown in the figure. The standing part of the pendant being hitched around the davit-head, the other end reeves through the peculiarly-shaped pendant-block D, attached to the boat, thence through a leader F, also in the boat, and is finally reeled up on a roller mounted athwartships of the boat and turning in trunnions. The ends of the two pendants are taken in opposite directions through a hole in the roller, but are not otherwise secured to it. It is found that as thus placed, a few turns around the roller makes them secure from unreeving unless the roller is free to turn.

For controlling the roller, another line is reeled up on it, one end of which is made fast to it. When the boat is hoisted and secured, this controlling or "lowering" line has a few turns around the roller, and is belayed to a cleat, the fall being coiled down in the boat. To lower, this line is slacked around the cleat, allowing the roller to turn under the tension of the pendants. Thus, as the pendants unreel the lowering line reels up. To release, the lowering rope is let go, the roller turns freely and the pendants unreeve, leaving the boat clear.

The three-sheaved block D is an important part of the apparatus. The manner in which the pendants pass around these sheaves results in considerable friction, the amount of which depends upon the size of the pendants as compared with the size of the rollers and the distance between them. Thus the friction can be made little or much, in proportion to the weight of the

Plate No. 64.

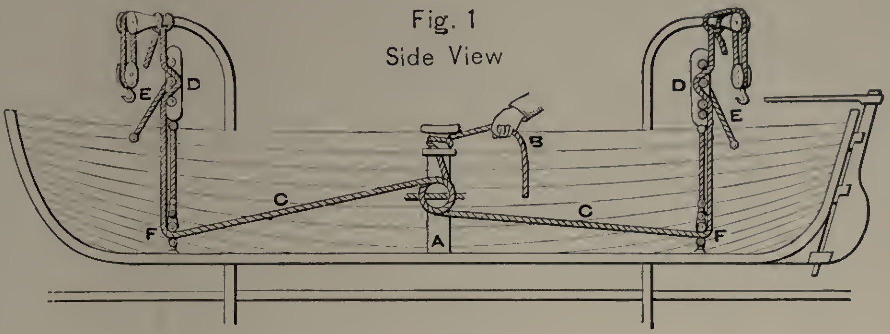


Fig. 1
Side View

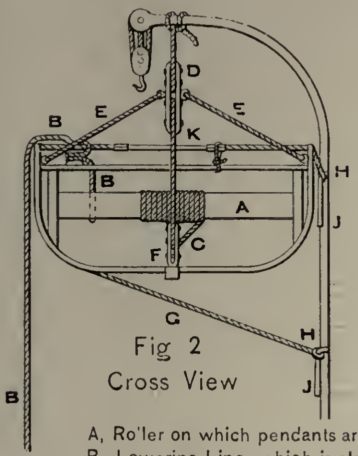


Fig 2
Cross View

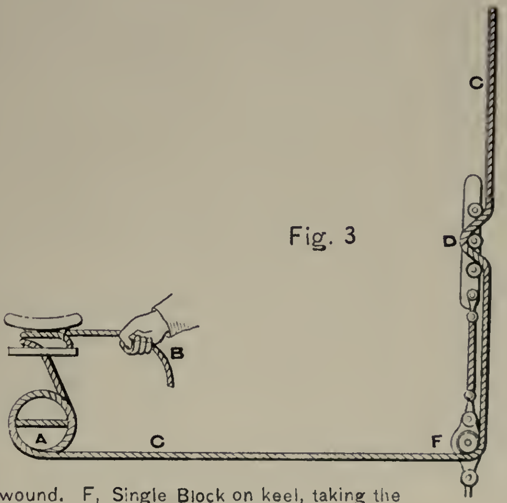


Fig. 3

A, Roller on which pendants are wound.
B, Lowering Line, which is slacked off when lowering.
C, Pendants.
D, Three Sheave block, the nip giving controlling power.
E, Steadying lines, to prevent the boat from canting.
F, Single Block on keel, taking the weight of the boat.
G, Boat's gripes in two parts.
H. Thimbles at each end of gripes, which pass down prongs.
J. Prongs down which the thimbles pass as boat is lowered.
K, Lanyard for setting up gripes.

CLIFFORD'S LOWERING GEAR.

boat; a heavy boat calling for more friction than a light one. The friction, if properly proportioned to the boat, relieves the tension on the pendants and the roller, and insures steady lowering.

For boats using the old style hook-and-link, it is well to have the link on the lower block of the fall and the hook on the span in the boat. If the hook is on the block, there is danger that it will catch under a thwart or some other part of a boat which is thrashing alongside trying to hook on in a rough sea.

Where boats are hoisted in and out by a yard-and-stay tackle or by a fall from a boom (as in the case of men-of-war boats carried inboard), a span must be used from the bow and stern, and steadying lines from the sides.

Plate **60** shows a method of fitting such a span, suitable for heavy boats.

Carrying a Quarter-boat Rigged Out.

Nearly all ships carry a quarter-boat ready for lowering in the event of a man overboard. The boat is griped in to prevent swinging, the gripes being secured by a toggle which can be slipped in an instant. The sea-painter is secured, life-lines hung from the span, the falls clear for lowering, the plug at hand, life-belts inside, the steering-oar in its crutch, water, provisions, lantern, etc., in place.

To Lower a Boat at Sea in Bad Weather.

Having to lower a boat at sea, a lee boat is always selected, a lee being made, if necessary, by changing the course of the ship.

It is customary to bring the sea a little on the bow, but in this position the lee for the boat is very far from perfect. The ship will roll and pitch considerably, and waves will wash along to leeward, making things very ugly at times. Some seamen prefer to bring the sea on the quarter rather than the bow. Others advise lying in the trough of the sea notwithstanding the heavy rolling.

The best position will doubtless depend upon the build and trim of the ship and the nature of the sea. In any case, oil should be used both ahead and astern of the boat. The ship should be kept moving slowly ahead. A painter should be used from well forward in the waist of the ship, brought into the boat through the inboard bow rowlock and tended by the second bow oarsman with a turn around the thwart. It must not be made fast.

To keep the boat from swinging, frapping-lines may be passed around the falls, the ends leading inboard and holding the boat close in to the side as it is lowered. In some ships jackstays are fitted from the davit-heads to the side of the ship, with lanyards travelling up and down. A turn is taken with the lanyard under a thwart or around the standing part of the fall and the boat is held in, near the side, as by the frapping-line above described. Under no circumstances should the lanyard be secured to the boat otherwise than as described (by passing it under the thwart and holding on by hand). Life-lines hanging from the davit-head and from the span assist in steadying the boat and give the crew something to hold on to in case of accident. A hatchet in the boat is handy if anything jambs at a critical moment.

The great danger, both in lowering and immediately afterwards, is that the boat will be dashed against the side. The boat rope brought in on the inner bow as already described helps to sheer her off as she strikes the water, and the helm may be lashed hard-over toward the ship for the same purpose.

A steering-oar is better than a rudder, and where it is used the coxswain sheers the bow out by throwing the stern in as the boat strikes the water.

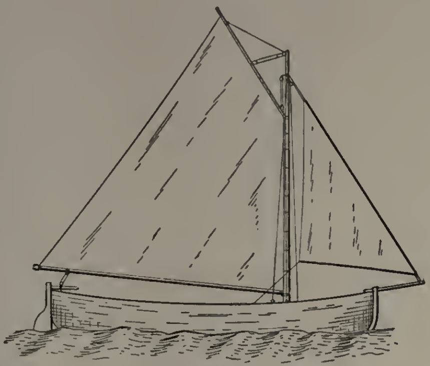
The after fall is always unhooked first.

Under no circumstances short of the most imperative necessity should a boat be lowered while the ship has sternway, and it is always desirable to have a little headway. There is much difference of opinion as to the speed at which it is safe to lower a boat, an important question in picking up a man overboard. Many officers, having seen boats lowered without accident at speeds as high as eight and ten knots, maintain that it is perfectly safe to lower at this speed. A more conservative view fixes the maximum at something like half this speed. It is safe to say that there is far less danger at five knots than ten, and most practical men would prefer to wait a little longer rather than to take the chance of having to deal with a whole boat's crew in the water.

Lowering a Stern Boat.

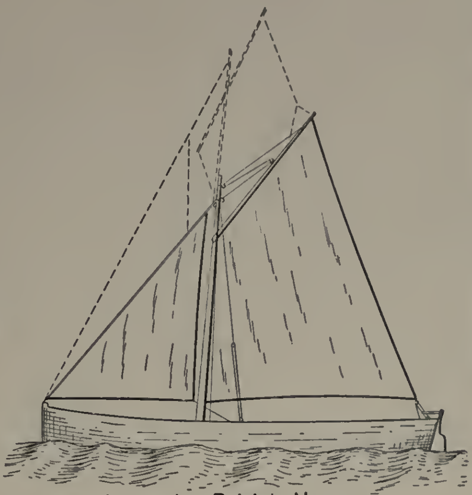
Here, as soon as the boat touches the water, the after fall is let go altogether and the boat allowed to swing at once parallel

Plate No. 65.



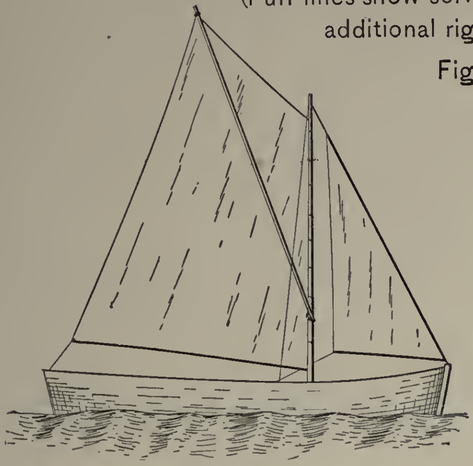
Launch—U. S. Navy.
(Gaff and Boom Rig).

Fig. 1



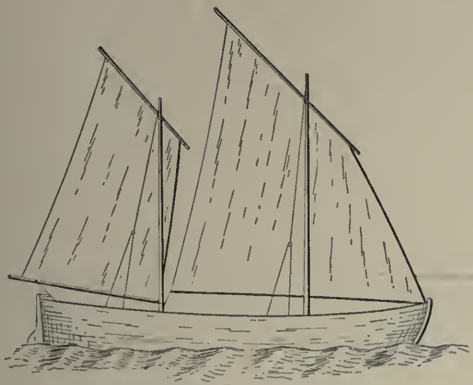
Launch—British Navy.
(Full lines show service rig; dotted lines additional rig for racing).

Fig. 2



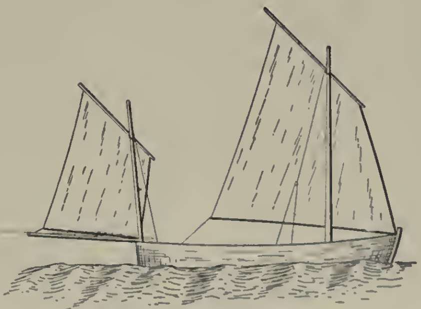
Sprit Rig.

Fig. 3



Dipping Lug Foresail and
Standing Lug Mainsail.

Fig. 4



Dipping Lug Foresail and
Standing Lug Mizzen.

Fig. 5

RIG OF BOATS FOR SAILING.

to the course of the ship, towing by the forward fall, which is then unhooked or, in an emergency, allowed to unreeve.

Hoisting.

To hook on and hoist a boat in a seaway is quite as difficult as to lower and detach it. The boat should be hauled up under the falls by a sea-painter from well forward, the helm or steering-oar being carefully attended. The important point is to keep her off from the side to prevent being dashed to pieces. The falls should be manned on deck and the blocks overhauled down, with an officer on the rail to give the word for hauling taut. Frapping lines around the falls may be used as already described for lowering. Oil should be used freely to calm the sea. If the ship is underway, she should steam slowly ahead and in this case a long painter should be used from the stern of the boat, leading aft, as otherwise she will launch violently forward as soon as she leaves the water. Both falls should be ready for hooking; then, all being ready on deck, watch for a smooth time, hook on forward, then aft, *Haul taut! Hoist away!*

§III. RIG OF SHIPS' BOATS FOR SAILING.

It is not to be expected that a boat built for a great variety of purposes, of which sailing is by no means the most important, should sail as if designed for that purpose alone. Not only must the lines and dimensions of the boat be regulated by the demands of general utility, but even the rig for sailing must be fixed by quite other considerations than those of speed and weatherliness. The spars and sails must be light and easily handled, and must stow compactly when the boat is under oars. They must admit of carrying passengers and stores, of coming alongside safely, of hooking on and hoisting conveniently. The fewer, shorter and lighter the spars, the better. Masts, especially, should be short and light, easily stepped by a few men, and calling for little support from shrouds and stays. Bowsprits and booms are particularly inconvenient, as are also the bumpkins which in some rigs project beyond the stern. A rig which entails danger of capsizing if it chances to be caught aback is of course objectionable.

Of the rigs considered suitable for man-of-war boats, the most common are the following:

1. **A gaff and boom mainsail** with bowsprit and jib. Used in the United States Navy for launches (Plate **65**, Fig. 1).

2. **A gaff mainsail without a boom** and a jib without a bowsprit. Used in the English Navy for launches, and called, from the admiral who introduced it, the "De Horsey" rig (Plate **65**, Fig. 2). A topmast is sometimes added to this rig, making it possible to carry a gaff-topsail and another jib.

The arrangement devised by Admiral de Horsey for handling the mast of this rig is of such convenience that it might well be adopted for all boats having rather heavy masts to be stepped and unstepped. The mast is mounted on trunnions at the height of the thwarts and as it is lifted, turning about these trunnions, the heel is guided into the step by a light frame shaped to the arc about which the heel moves.

3. **The dipping-lug.** Used in the English Navy for pinnaces and cutters, usually in combination with a standing-lug main or mizzen (Plate **65**, Fig. 4).

4. **The standing-lug.** Used in the German Navy for cutters, and in the English Navy for the main and mizzen of cutters and whale-boats (Plate **65**, Fig. 4).

5. **The balance or French lug.** Used in the French Navy for cutters (Plate **66**, Fig. 4).

6. **The sliding-gunter.** Used in the United States Navy for cutters, whale-boats and gigs; in the German, French and most other navies, for whale-boats (Plate **66**, Fig. 1).

7. **The sprit.** Used very generally for dinghys and other small boats (Plate **65**, Fig. 3).

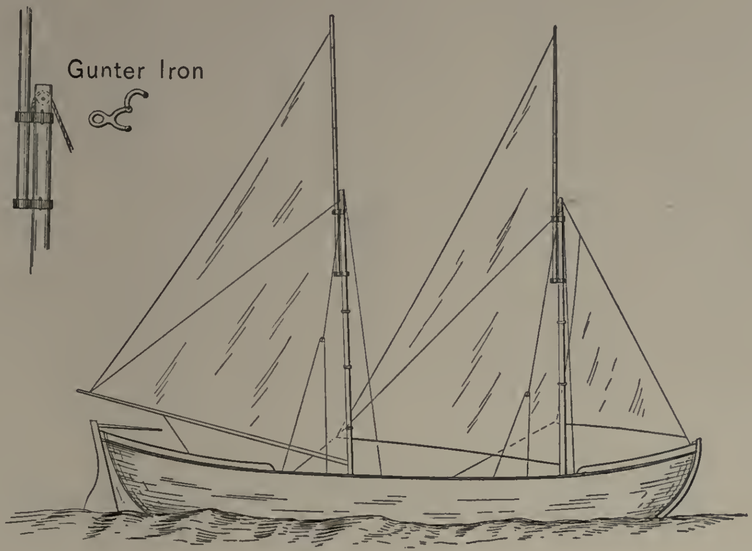
Of these rigs, the dipping-lug is commonly regarded as the best for speed and weatherliness, but it is hard to handle and even dangerous with any other than a very smart and well-drilled crew.

The standing-lug is safe and convenient to handle, but lacks something of the driving power of the dipping-lug.

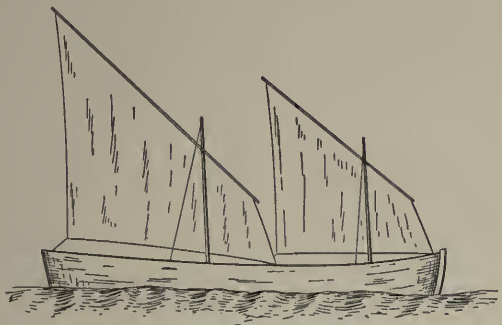
The French lug is a compromise between the two preceding rigs and combines many of their advantages. It may, in fact, be used either as a standing- or as a dipping-lug, the forward yardarm being dipped if either. If it is not dipped, the yard lies to windward of the mast on one tack and to leeward on the other. This rig perhaps combines as many points of excellence as any that could be named.

The details of rigging for lug sails vary considerably, but the yard is always attached to the mast by a traveller moving freely

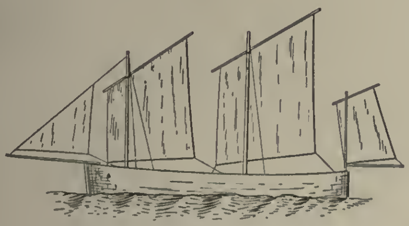
Plate No. 66.



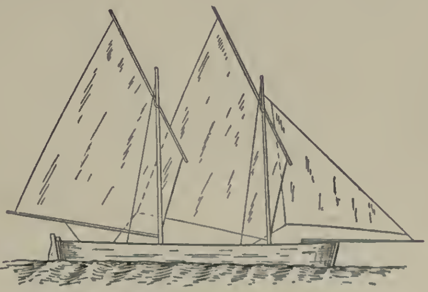
Sliding Gunter
Fig. 1



Low Dipping Lugs
Fig. 2



Balance (French) Lug
Fig. 3



Standing Lug
Fig. 4

RIG OF BOATS FOR SAILING

up and down. The halyards are usually rove through a sheave in the mast, but sometimes through a block at the mast-head. A down-haul should always be fitted and it is convenient to use for this the bending end of the halyards. As a rule, no shrouds are used, but the halyards are set up to windward and abaft, and serve to support the mast, except in cases where the forward yard-arm dips; in which cases the halyards lead down forward of the mast amidships. The most convenient way to fit the halyards is to use a pendant with a single block at the end, through which a fall is rove.

In the English Navy the larger cutters carry a dipping-lug foresail and a standing-lug mainsail, the latter being replaced in cutters of twenty-seven feet and under, by a mizzen stepped at the extreme stern of the boat with a bumpkin rigged out beyond the stern for the sheet. As the mizzen is of necessity a small sail, the foresail must be large, to give a fair spread of canvas, and being a dipping-lug it is not convenient to handle. In spite of this and the seeming clumsiness of the mizzen, with its boom and bumpkin projecting from the stern, this rig is much liked in the English service. It involves very little gear, and is quickly and easily rigged. The greater part of the sail area, being in a single sail reaching well out to windward and with nothing forward to becalm it, is favorably placed for holding a wind; and boats with this rig sail faster on a wind than those with their canvas divided between a fore and main; but they are at a disadvantage in reaching, and they do not lie-to well. The forward part of the foresail acts as a jib, but with greater pull and smaller leverage; and the absence of a bowsprit is an advantage in going alongside and in plunging into a head sea.

The halyards of a dipping-lug are bent one-third of the length of the yardarm from the forward end. The tack is usually hooked to the stem, except in sailing free, when it is shifted to the weather bow. Some seamen prefer to hook it always to the bow, but the boat will not point quite so high with it there. The most serious danger connected with the lug arises from the fact that if the sail gets aback, it binds against the mast and cannot be lowered. In this situation, in a fresh breeze, there is serious danger of capsizing. It is a good plan to make the tack fast with a "slip-hitch," which admits of casting it off in an instant, when the sail immediately spills, as it is a characteristic of the lug that its stability depends entirely upon the tack.

The dipping-lug sometimes takes the shape of Fig. 2, Plate 66, which, it will be seen, is an approach to the latteen rig. Here the forward yardarm is the one to be dipped, and the luff is short enough to admit of dipping without lowering the yard. The tack makes fast amidships, a light jigger being used to get it well down. The halyards are led down forward, close in to the mast, and, as in all cases where the halyards are not available for supporting the mast, the mast must be stout and well secured at the partners. Like the French rig already described, this rig, although designed for dipping, will work fairly well as a standing-lug. It is well suited for boats like gigs (old style) which are not built for sailing and have not the stiffness to stand up under a rig whose center of effort is high.

The tack of a standing-lug is made fast to the mast, and the halyards are bent one-fourth of the length of the yardarm from the end. With the balance-lug, the tack may conveniently be fitted to travel across on an iron rod or "horse" just forward of the mast. The point for bending the halyards varies.

The sliding-gunter is one of the safest and most convenient of rigs for boats of small and medium size, but it has comparatively little driving power, particularly on a wind, and for all-around work is distinctly inferior to several of the rigs that have been mentioned above. Sail is reduced in an instant by letting go the halyards, and taken in altogether by tricing up the boom (or clew) as the topmast comes down, brailing up at the same time. This is done as easily with the sails aback as when they are full. On the other hand, the spars are awkward to handle, and still more awkward to stow, since the lower mast, topmast, and sails are usually made up together. This makes it inconvenient to carry the rig in the boat when under oars and impossible to do so if the oars are to be used in rough water. It is a great improvement to make the gunter irons with clamps so that the topmast and sail can be stowed separately from the lower mast. A good deal of power is required to step the masts in shifting from oars to sail, particularly if the boat is rolling. In spite of these disadvantages, the rig holds its own in the United States Navy, though many officers of the service have a decided preference for the French lug.

The halyards of the sliding-gunter are bent to the neck of the upper gunter-iron and lead through a sheave in the mast. The clewrope leads from the clew to the proper point on the mast for tricing up the boom snugly.

§IV. HANDLING BOATS UNDER SAIL.

TRIM.—To do her best under sail, a boat must be trimmed in accordance with her build and rig.

If she carries considerable head sail, she will need to be deeper forward than would otherwise be desirable. If she has little or no head sail, she should trim by the stern. The build and rig are fixed upon with reference to each other, due consideration being given to the purpose for which the boat is designed. Once fixed, these characteristics are practically permanent. The *trim* of both boat and sails, on the other hand, can be varied within rather wide limits; but they, too, must be considered with reference to each other. Most boats when on the wind sail best when carrying a little weather helm; that is to say, when they have a slight tendency to come into the wind. Too much weather helm may be corrected by shifting weights aft; too much lee helm, by shifting forward.

The weights should be kept out of the ends of the boat, without being unduly crowded together amidships. It is especially important to keep heavy weights out of the bow. The only ballast, *as such*, that should be carried, is water in breakers. Under no circumstances should "sinking" ballast be allowed; ballast, in other words, which is heavier than water. The lower the weights can be stowed, the better; but care should be taken to keep the *well* clear for baling. Ballast and cargo must be secured against the possibility of shifting. The crew should be kept well down and nobody allowed to stand on the thwarts or to sit on the gunwale. If the men are sitting to windward in a fresh breeze, they should move amidships for passing under the lee of a vessel or other object, where the wind may fail or even shift in an eddy. The mast should be properly stayed, up and down or with a slight rake aft, and the halyards taut up.

In a lug rig, the halyards act as a weather shroud, the tie being led down to windward and abaft, and set up by a two-fold purchase. In most other rigs, shrouds are fitted.

On the wind, as has been said, a boat should carry a little weather helm. The sails should be kept well full, sheets not too flat, but everything drawing and the boat *alive*. It is a common mistake to get the sheets so flat that the boat, while pointing high, actually makes a course to leeward of that which she would make if kept away a little with sheets eased accordingly; and it is of course clear that if kept away, her speed will be greater than when jammed up into the wind in the hope of stealing a fraction of a point. A boat of good draft with a deep keel or centerboard, and yachts designed for racing, with fin-keels hanging ten feet below their normal draft, will lie amazingly close to the wind with little or no leeway. Ship's boats, however, are not constructed on yachting lines and cannot be held up in the same way.

Sheets may be hauled flatter in smooth water than in rough, and the sheets of standing lugs, gaff- and boom-sails, sliding-gunters and the like, may be hauled flatter than those of dipping-lugs. The sails being properly set, the weather cloths of the sails are kept just trembling, with weather helm enough to let the helmsman "feel" that she wants to come into the wind. As the wind will vary more or less (in apparent, if not real, direction), it is necessary to be watchful and to bring her up or keep her away from time to time in order that she may be always at her best. The sails should be kept fuller in rough than smooth water, and it is more important that the boat should be kept *going* so as to be always under command of the helm. If a heavy breaking sea is seen bearing down upon her, she should be luffed to meet it and kept away again as soon as it has passed. If she loses way she becomes helpless at once. It is dangerous to be caught by a heavy sea on the beam; and if the course to be made in rough water would bring the boat into the trough of it, the best plan is to run off for a time with the sea on the quarter, then bring her up with it on the bow, and so to make good the course desired without actually steering it at any time.

It is a universal rule in boat sailing that the sheets should never be belayed in any weather.

For a moderate squall, the boat should be luffed sufficiently to shake, without spilling, the sail, thus keeping headway enough to retain control, but with the sheet (as always) in hand. If it comes stronger, she must be luffed more decidedly and the sheet slacked more or less. The sheet may of course be let go, and in a sudden emergency this must be done at once in addition to putting down the helm, and, if necessary, reducing sail; but the longer she can be kept under control the better, and to let go the sheet is to give up control.

The situation is quite different in running free. Here the sail cannot be spilled by a touch of the helm, and the only prudent thing is to slack the sheet while luffing. The force of the wind would be much reduced by running off, but the trouble with this is that if it comes too strong there is no resource but to lower the sail, and the chances are that it will bind against the shrouds and refuse to come down. Moreover, there is always danger that the wind will shift in the squall, and the mainsail may gybe with dangerous force.

REEFING.

When a boat begins to take in water it is time to reef. And she should never, even in smooth water, be allowed to heel too much. A boat that is decked over may run with her lee rail awash; but when an open boat is approaching this point it must be remembered that a fresher puff may bear the gunwale lower without warning, and that the moment it dips, the boat will almost certainly fill and capsize. The details of reefing will depend upon the rig, but a few general rules may be laid down. The men should be stationed before beginning, and should all be required to remain seated. One hand lowers the halyards as much as may be necessary, another hauls down on the leech and shifts the tack. The sheet is hauled in a little to let the men detailed for the reef points get hold of and gather in the foot. The sheet is then slacked and shifted, the points passed, the halyards manned, the sail hoisted and the sheet trimmed. It is important to keep the boat under command while reefing, and for this she must have way enough to obey her helm. If she can be luffed a little and still kept going through the water sufficiently to obey her helm, then it is unquestionably wise to luff, but not sufficiently to risk losing control by the helm.

If the boat has more than one sail, it is a good plan to reef them one at a time.

RUNNING BEFORE THE WIND.

This is the most dangerous point of sailing in a fresh breeze because of the chance of gybing. The danger increases if the boat yaws, as she will have a tendency to do if trimmed at all by the head; from which follows the rule, in running, to keep the weights fairly well aft, though never at the extreme after end. Very careful steering is required; and if the sea is really heavy, the chances are that the boom will gybe in spite of all the care that can be taken, unless lashed to the rail or a shroud by a "lazy guy."

Squalls are not so dangerous before the wind as when close-hauled, unless they are accompanied by a shift of wind.

If they call for any reduction of sail, it may be made by dropping the peak of the mainsail (if a gaff sail) or, more satisfactorily, by reefing.

The foresail is sometimes set on the side opposite the mainsail, in running before the wind, a temporary boom being rigged by using a boat-hook or an oar. A boat sailing in this way is going "wing and wing."

If the sea is rough, it is well to avoid running with the wind dead aft. To make a course directly to leeward, the wind may be brought first on one quarter and then on the other, the mainsail being clewed up on the peak dropped each time the course is changed, if the breeze is strong enough to make gybing dangerous.

A serious danger in running before a heavy sea is that of "broaching-to." The boat will yaw considerably, the rudder will be often out of water when it is most needed to meet her, and the sails will be becalmed in the trough of the seas. The situation here is much like that of a boat running in a surf; and, as in that case, the yawing will be reduced by keeping the weights aft and by steering with an oar. The jib should always be set, with the sheet flat aft. It helps to meet and pay her off if she flies to against the helm. A drag towed over the stern is also helpful.

Another danger in running is that the boom may dip as she rolls and thus capsize the boat.

TACKING.

In tacking, the same principles apply to a boat as to a ship. After-sail tends to bring her head to wind, head-sail to keep her off; but all sails, so long as they draw, give her headway and so add to the steering power of the helm.

It is clear that a short full boat will turn to windward better than a long and narrow one and will require a much shorter distance for coming round. Thus a short boat is preferable to a long one for working up a narrow channel.

Under ideal conditions, a boat close-hauled but with good way on, shoots up into the wind as the helm is eased down, making a good reach to windward and filling away on the new tack without for a moment losing headway. The main boom is hauled amidships, and, as the jib and foresail lift, their sheets are let go. The boat comes head to wind and as she pays off on the new tack the sheets are hauled aft and she is steadied on her course. Under less favorable conditions, tacking is not so simple. If there is a sea on the bow advantage must be taken of a smooth time to ease the helm down; the main boom must be hauled amidships gradually, and the foresail kept full as long as it will draw. If the boat loses headway, the jib sheet is held out on the old lee bow (not too far) to pay her head around, and care must be taken not to make a "back-sail" of the mainsail. As she gathers sternway, the helm is shifted, and, if necessary, an oar is gotten out to help her around. Carrying the weights forward is favorable for tacking, but when a boat has sternboard she may be helped around by putting a few of the crew on the (new) lee quarter, where, by increasing the immersion of the full lines of the counter, they add to the resistance and cause the bow to fall off.

If she gets "in irons," either an oar must be used or the jib and foresail sheets must be hauled over on the old tack, flat aback, to give her stern board. This last is a dangerous maneuver in a strong breeze and rough sea.

WEARING.

In wearing, the helm is put up and the main sheet slacked away roundly. The boat goes off before the wind, the mainsail is either gybed, or clewed up and shifted over (preferably the latter) and the boat is hauled up on the new tack, losing more or less ground to leeward according to circumstances. The details of the maneuver may vary considerably according to the conditions of wind and sea and the peculiarities of the boat as to rig and trim. In a light breeze, the main sheet is slacked away roundly until the wind is aft, then hauled in smartly for gybing and eased away steadily on the new lee quarter. In a fresh breeze, as gybing would be dangerous, the mainsail is clewed up just before the wind comes aft, and set again in time to bring her to the wind on the new tack.

The fore and jib sheets are shifted when nearly before the wind. As she comes to on the new tack, they are left flowing until hauled aft to meet her by the wind.

REMARKS ON GYBING.

A sail is "gybed" when it is allowed to swing from one side to the other, the wind being aft or nearly so, and the sail full first on one side and then on the other. This may be done intentionally, as in wearing or in changing course, or it may come unexpectedly from a shift of wind or from the yawing of the boat. As it necessarily involves a violent swing of the sail, it puts a heavy strain upon the spars and fittings and causes the boat to lurch more or less deeply to leeward. Moreover, the violent sweep of the boom across the stern endangers everybody in its path.

In a light breeze, these dangers are perhaps not serious enough to justify the rule that a mainsail should never be gybed, but in a fresh breeze it should not be thought of; and the fact that it is often done by experienced boatmen does not make it any more seamanlike.

When a necessary change of course in a fresh breeze will bring a shift of wind from one quarter to the other, the sail should be lowered or clewed up for a moment before putting up the helm, and then set again on the other quarter. If this cannot be done and it is still necessary to gybe, the peak should be dropped, the boom hauled in slowly and eased away on the new tack.

§V. HANDLING A BOAT UNDER OARS.

There is perhaps quite as much art in handling a boat under oars as in handling it under sail, but comparatively little of this art can be taught by precept. The greater part of what follows relates to man-of-war boats and deals with principles of drill and discipline rather than of seamanship. There is of late years a tendency in all navies to rely very much upon steam-launches, and as a consequence of this it has become rare to see man-of-war boats handled with the smartness which characterized the best of them not many years go. Yet the need of just such training as produced this smartness is greater now than ever before, because of the changes which are making of the modern men-of-war's man a mechanic and a soldier rather than a sailor.

Suppose a cutter manned and lying at the gangway, ready to shove off. The boat officer sees that the boat is in perfect condition and the crew in uniform. The bowmen stand up in the bow, holding on with boat-hooks to the side or the grab-rope, the rest of the crew have their oars in hand.

The order is given:

Get your oars ready!

Each man sees his oar clear and stands by for the next order.

Up oars!

The oars are lifted together and held vertically, blades fore and aft and in line.

Shove off!

The bowmen point their boat-hooks against the side and shove well clear and a little ahead, the coxswain sheering her off with the helm. Fenders are taken in.

When the boat is clear,

Let fall!

The oars are dropped into the rowlocks, the blades not being allowed to splash, and are instantly brought level with the rail, blades horizontal and trimmed with the after oars.

Give way together!

The bow oarsmen take their places as soon as they have shoved off, get their oars ready, raise them together, touch the blades, let fall, and take up the stroke.

To come alongside, the order is given while still several boat lengths from the gangway or landing,

In bows!

The bow oarsmen finish the stroke, then toss and lay in their oars together, after which they take their places in the bow, standing erect, facing forward, and each holding his boat-hook vertically in front of him until it is needed.

When having way enough to make the gangway properly,

Way enough!

This order should always be given while the oars are in the water. The stroke is completed and one more stroke taken, then the starboard stroke oarsman commands

Toss!

The oars are tossed and held vertically for an instant, then laid in together. The fenders are thrown out.

With awnings spread, see that the stops are cast off before the order "Way enough!"

If the boat is to remain alongside only a moment, it is better merely to toss, and to keep the oars up until ready to shove off.

With a cutter or other boat whose rowlocks are cut into the rail, many officers prefer not to get up the oars for shoving off, but to point the blades clear just over the rail, then to throw them smartly around into the rowlocks at the order **Out oars!**

With awnings spread, the oars cannot be "tossed." After the boat is clear of the ship's side order, **Out oars!**

The oars are thrown around into the rowlocks, blades horizontal and level with the gunwale; awning stops made fast.

To lay on oars, the order is,

Oars!

This order is given while the oars are in the water. The stroke is completed, and the oars at once raised to the level of the gunwale and trimmed together, with blades horizontal.

To check the headway of the boat,

Hold water!

The blades are dropped into the water and held vertically there.

If this is not sufficient,

Stern all!

At this the oars are backed, keeping stroke as regularly as when pulling ahead.

To toss oars, the order is,

Stand by to toss! Toss!

The preparatory order is given while the oars are in the water, the order of execution just as the stroke is completed.

To turn the boat short around, say to starboard,

Back starboard! and if necessary, **Give way port!**

Single-banked boats trail their oars instead of tossing. When such a boat is ready to shove off, the oars are resting in the rowlocks with blades in the water and pointing aft; or if for any reason they cannot be left in the rowlocks, they lie in the water alongside, held by their trailing lines.

In shoving off, as soon as the boat is clear of the side, the orders are,

Out oars! Give way together!

In coming alongside, the order to the bow oarsman is:

Trail bow! or simply **Bow!**

After "way enough," the stroke oar gives the order

Trail!

In going into a crowded or difficult landing, pull easily and keep the boat under control with the oars as long as possible.

In going through a narrow entrance, get good way on the boat, then trail or toss the oars.

Remember that a loaded boat holds her way much longer than a light one.

In pulling across a current, try to get a *range* of two objects in line and steer by these to avoid being set down by the current.

Having a long pull against the tide, run inshore where the tide is slacker than in midstream.

If the weather is thick or may become so, make sure you have a compass in the boat, and note the course you must make coming and going.

At sea never leave the ship without a compass, water and provisions in any weather.

There should always be a lantern in the boat filled and trimmed.

If taken in tow by a vessel, make her give you a line instead of taking your painter, and keep this clear for letting go in an instant. If towing astern, hold on with a short line close up under the counter; if towing alongside, have a long line and watch your steering.

Never go alongside a vessel when she has stern way. In a seaway always board a vessel to leeward, unless there is wreckage floating alongside.

(See Chapter "Rescuing the Crew of a Wreck.")

In coming alongside in a seaway or a strong tide, warn the bow oarsmen to look out for the line which will be thrown from the ship.

Caught in a Gale in a Boat.

Rig a sea-anchor by lashing the spars and sails together, the sails loosed. Fit a span to this and ride by the painter. If there is oil in the boat, use a bag of it on the sea-anchor.

Running a Line.

Coil the greater part of the line in the stern sheets, but take end enough in the bow to make fast when you reach the landing. Pull away and let the ship pay out more line until you are sure of having enough in the boat to reach, then pay out from the boat. Always have plenty of good seizing stuff for making all secure, and if you are to stand by the line, have an axe for cutting if ordered.

If laying out with the tide, take less line in the boat than otherwise; if against the tide it will save work to take all the line in the boat, pull up and make fast, then bring the end back to the ship. With a long line to be laid out in a strong current, it will usually be necessary to have several boats, one to run away with the end, the other to underrun at intervals, floating the line and pulling up stream with the bight.

If the line is to be secured to a post, put a bowline in the end before starting, and throw this over the post. Bend on a heaving line and let the bow oarsman throw this if hands are standing by to take it, or jump ashore with it himself if necessary.

§VI. NOTES ON THE HANDLING AND CARE OF STEAM LAUNCHES OF MEN OF WAR.[1]

The laws governing the steering of a steam launch are identical with those laid down in Chapter XIII for the handling of single-screw steamers.

In making a landing, whether at a dock or at a ship's gangway it is a common mistake to keep too much way and to rely upon backing full speed to stop the boat at the proper point. This is bad seamanship. The engines may and often do fail to respond promptly, and when they do respond, the sudden backing throws an undue strain upon the engines and upon the rudder-stops. Moreover, the backing throws the stern off to one side or the other—according as the screw is right- or left-handed. In coming alongside a ship's gangway, in a current, care must be taken not to catch the tide on the outboard bow, as this will sweep the bow in, forward of the landing platform and perhaps underneath it, with the result that the boat may capsize or be swamped. The landing should be made by the aid of a boat-line from forward, the boat being kept off a little from the side until the line is fast and then sheered in by the helm.

A boat may lie alongside safely in a strong current with a line from the inner bow and the helm slightly over toward the ship.

In towing, the stern of the boat should be kept well down by shifting weight aft if necessary. This keeps the propeller well immersed and gives it a good hold on the water.

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[1] All remarks upon boilers in this section refer to the water-tube type.

When running in a seaway, speed should be reduced somewhat, not only to avoid shipping seas, but to reduce the strain on the machinery due to the "racing" of the screw. In running into a sea, it is possible by careful nursing to make fair speed, watching the seas and slowing or even stopping for a moment as heavy ones are seen bearing down upon the boat. If the man who is running the engine has sufficient intelligence and experience to regulate the speed in this way (assuming that he can see) it is convenient to leave it to him. If running more or less across the sea, it is well to head up momentarily for a heavy wave.

Each steam launch should have two crews, assigned to different watches in the engine room, so that there will always be one crew off duty and ready to go in the boat when the ship enters or leaves port, without calling upon men to leave their stations in the engine room. Any man of ordinary intelligence can soon be taught how to do the routine work required of the fireman and coal passer, provided that one of the mechanics of the ship exercises occasional supervision of the machinery and keeps it in repair.

When a vessel is about to enter port notice should be given one-half hour or more in advance to the fireman in charge of the launch, who should see that the boat is supplied with wood, coal and fresh water, that all parts of the machinery are connected, that bolts, nuts, keys, split pins, oil cups, steam- and water gauge lamps are in place, all usual and necessary tools on board, the boiler filled to proper level with fresh water, the cocks at the top and bottom of the water gauge open, the furnaces coaled and wooded ready to light, and the engines oiled and turned by hand.

The water used in the launch boiler should always be obtained by distilling on board. Fresh water from shore often contains corrosive ingredients or lime salts, and should never be used unless chemical tests show that it is free from these impurities.

When the launch is about to be lowered the fires should be started promptly and steam got ready to try the engines by the time the boat is in the water. As soon as the launch is in the water, if not before, the feed pump or pumps must be worked by steam, the engines turned back and forth, the whistle, safety valve and bell tried. If at such times any of the machinery fails to work it is better to try to discover the cause by reasoning and by simple experiments rather than to use up time taking the machinery apart to see what is wrong inside, and to run the risk of twisting off studs, losing nuts and spoiling gaskets.

If an engine or pump stop-valve is detached from its stem, no steam gets to the engine and none comes out of either cylinder drain.

If steam comes out of both cylinder drains at the same time, the slide valve must leak.

If opening the drains shows that there is a good head of steam against one side of a pump piston and the piston does not move, then there may be a stop valve shut in some part of the exhaust pipe, or a stop valve in the exhaust pipe may be off its stem and kept shut by the pressure of the exhaust steam.

If on opening the drains it is found that there is a good head of steam acting against the piston and the piston does not move, shut off steam and open the drains on the water end and let out the water, then use a lever and try to move the pump piston by hand and see if it is stuck. It may be stuck from the steam piston being rusted in place, or from the piston rod stuffing box being set up too tight when the rod is worn unevenly, or the packing in the water cylinder may be too tight when the water cylinder is worn barrel shape.

If the pump starts, makes a few strokes and stops, it would indicate a valve in the exhaust closed, or a check closed.

If the pump runs but does not throw water, the causes may be:

(a). The water in the feed tank is too hot so that vapor forms in the pump. The vapor can be condensed by pouring cold water over the pump.

(b). One or more of the suction or delivery valves may be unseated or stuck open by waste under them. In this case it will be necessary to remove one or more bonnets to get at the valves.

The pump may run and throw water so that a strong jet comes out of the pet cock on the discharge side and yet no water gets into the boiler. This may be due to the pump piston or valves leaking under boiler pressure, yet not so much as to prevent the pump throwing water under atmospheric pressure, or even a little above. If such leak is suspected, try reducing the boiler pressure to see if the pump will feed at any pressure and thus enable the boat to continue in service until opportunity occurs to repack the piston or refit the valves.

The pump may make a few strokes then gradually slow down and stop.. This would indicate that the check valve was stuck, or the stop valve at the check was detached from its stem. If the check is stuck, it can often be loosened by rapping on the valve chamber with a light hammer or bar of iron. If the stop valve is off the stem, nothing can be done until the fires are hauled.

A most common cause of the failure of our naval pumps is the slipping of the tappets, and this is the first thing to be looked for.

Each type of engine and pump has its own peculiarities, which must be learned by experience. No pains should be spared to get all parts into thorough repair, and when the boat is not required for service no temporizing with machinery which works imperfectly should be tolerated. The labor required to go through the routine overhauling of all parts of the machinery is far less than the labor of repairing breakages which are sure to result from neglect of such systematic overhauling.

While the launch is alongside the ship the furnace should be fired as lightly as possible to avoid blackening the ship by the smoke that is given off when firing heavily. For the same reason the use of the steam jet is to be avoided at such times.

When the launch shoves off and gets fairly under way, the first point to notice is the vacuum, and if that is below normal, search must be made to ascertain the cause. The feed water should also be *tasted* to see if it is salt and this test repeated from time to time while the launch is in use. The firemen should carry a uniform steam pressure, fully up to that prescribed for the boat. Inability to do this shows something wrong with the engine, boiler, the coal, or with the men; and the exact reason should be discovered and the difficulty overcome. The most common causes of low steam are too heavy firing, too high water in the boiler, and tubes which require cleaning. Any kind of coal likely to be bought by men-of-war will burn well if *lumps* are selected for use in the launch. As the men gain experience and confidence in themselves and the feed pump, they are inclined to carry water lower than the normal level because they find that the boilers steam more freely. The principal danger to be anticipated from this is that a temporary failure of the pump may result in the water disappearing from the glass, in which case there is no way of knowing how little water may be in the boiler, and it might therefore become necessary to haul the fires. While under way the water in the gauge generally rises and falls with the motion of the boat. If it remains motionless, it would indicate that the gauge was choked. If the water in the gauge shows a muddy color, or a drop of oil floating on the surface, it would be an indication that the boiler needed cleaning badly. Absolutely no oil should be used in any steam cylinder except when the machinery is to be laid up for an indefinite time, say not less than several months. In this case it should be applied by removing the cylinder and valve chest covers, wiping over the surfaces with waste dipped in mineral oil and replacing the covers. A groaning noise, which often occurs in the L. P. cylinder of a compound engine, especially when the engines are slowed after running full speed, is not an indication that oil is needed in the cylinder. When the engines are in free route, a sudden slowing down is sometimes noticed. It may be due to an increased resistance encountered by the boat from changing the course bringing the wind from astern to ahead; or to the boat leaving deep water and running into shoal water; or to the propeller fouling or the helm being suddenly put hard over; or some bearing, especially a crank pin, may be heating, or the water in the boiler going over into the engine, or the vacuum may be spoiled by an air pump valve carrying away, or there may be a drop in steam pressure from improper firing, or the water in the boiler may be run up too high and too quickly. A hot crank pin or other bearing should never occur with such engines as are now used in launches. If water gets into the cylinder to any extent a knocking sound will be heard, and the drains cannot be opened too quickly. Such an accident ought to be most carefully guarded against as it is very apt to cant the piston and bend the rod. It is caused by irregular firing, carrying the water too high, the steam too low, or suddenly speeding up the engines.

If when the engines are in free route a sudden great increase in the number of revolutions is noticed, it is an indication that the propeller is lost or one or more blades are broken off. Slight increases may be due to the wind and change of depth of the water, &c.

In case the water cannot be kept in sight in the glass owing to failure of the pump or a leak in the boiler, it will be necessary to haul the fire. In this event a shovelful of live coals may be left in the furnace to start a new fire with. If the leak is so great that fires cannot be hauled without risk of scalding the fireman, there is no objection to putting out the fire with a bucket or two of water.

Every effort should be made to avoid the necessity for using salt water in the boilers, and to prevent it getting in from a leaky condenser. If the condenser leaks, the mixture of salt and fresh water from the air pump may be allowed to go to waste and fresh water from the reserve tanks used exclusively for feed provided those tanks carry enough water to last until the boat returns to the ship. If, however, it is necessary to use salt water, the boiler should be emptied and washed out with fresh water at the earliest opportunity, and if much salt water has been used it may even be necessary to use kerosene to remove the lime scale from the tubes.

Although the tubes of launch boilers are not found to corrode to anything like the extent that the tubes in the main boilers do, it is well always to keep the water in the launch boiler slightly alkaline by use of a small quantity of caustic soda or caustic potash in the feed from time to time when the launch is in use, and especially when the launch is hoisted; except that when the weather is so cold that there is danger of the water freezing, the boiler must be kept empty. The amount used should be just enough to turn red litmus paper blue.

In a seaway the water gauge glass must be screened, as cold spray striking the hot glass is apt to crack it. If the glass is broken the water level can be judged by using the pet cocks, or if none are provided, then by allowing the lower cock of the water gauge to drip slightly. A thumping sound is sometimes heard under the stern when the engines are running and the helm is suddenly put hard over or if the water is rough. This indicates that the bushing in the stern tube is much worn and needs renewal.

When a launch returns alongside of the ship the fireman should report to the coxswain before the latter leaves the boat what repairs or supplies are needed in order that the officer of the deck may get prompt information on these points.

When a launch is to be hoisted on board all necessary pipe joints must be broken and preparations made for removing the engine or boiler or both if the amount of repair work required renders it necessary. As soon as the boat is secured at the davits an inspection is made of the propeller to see that none of the blades are bent, that the nut is secure with its split pin, and that there has been no corrosion of the shaft close to the propeller hub. It frequently happens that the shaft corrodes deeply at this point and then a slight blow from the propeller striking a piece of drift wood or other obstruction breaks the shaft, disabling the boat and causing the propeller to be lost. If any blades are bent they can be hammered out to their proper form. If a blade is broken off it is sometimes practicable to have a new one cast on.

An examination must be made to see if the lignum vitæ bushing of the stern tube is worn down, and if it is a new spare bushing should be fitted. If there is no spare bushing or lignum vitæ block in store, a temporary bushing may be made of anti-friction metal.

All the under-water fittings of the rudder should be examined and put in good order. The keel condenser can be tested for leaks by filling with water and afterwards draining by removing the plug provided for that purpose. A question arises as to whether or not the keel condenser should be painted. It is inconvenient of access when the boat is hoisted, and unless cleaned daily it is an unsightly object if left unpainted when the bottom of the launch is painted. Paint protects the copper from corrosion when the boat is in the water but probably diminishes its conductivity to some extent.

The ship should carry a spare engine for the launch and there should be two feed pumps in the boat. If the ship carries two launches of about the same size they should have the engines of the same size and pattern, in order that one spare engine may do for both boats and all spare parts be interchangeable.

The following spare parts are usually provided: Boiler tubes, grate and bearing bars with their patterns, water-gauge glasses, brasses for the engine, propeller shaft, propeller, keel condenser. Except the special tube expander and steam-tube sweeper, such tools and stores as are found in the ship's storeroom will do for the launch. It is convenient to have on board in or near the machine shop, suitable pipe and connections arranged to facilitate testing the engines, boilers and pumps after they have been repaired and before they are replaced in the boat.

A water-tube launch boiler using only distilled water will usually last a cruise without cleaning. If, however, the boiler gets much scale or oil in it, the most effective way to clean it is to pump into the boiler with the feed water a few pints of kerosene lamp oil while the boiler is in use. The first effect of this will be to loosen up the dirt, and the water in the glass will appear very cloudy. Then blow down to the bottom of the glass and repeat the operation until the water in the glass gets clear.

When the engines and boilers are removed for repairs, an opportunity is offered for thoroughly cleaning and painting the bilges, repairing floor plates, water tanks, coal bunkers and such parts as are inaccessible at other times. New bearing bars and grate bars are to be fitted when required. The prolonged use of bent bars wastes coal and makes it difficult to keep up steam.

After the engines and boilers are repaired and replaced all bright work should be kept clean, the polished steel being covered with the thinnest possible coat of mineral oil, all oil holes plugged, and the engines and pumps moved by hand every day. The boiler may be painted with asphaltum or brown zinc. If the latter is used, it can be kept in excellent condition by wiping it over from time to time with oily waste. The best way to preserve the boiler is to keep it completely filled with water made slightly alkaline with caustic soda (or caustic potash) except in freezing weather, when it must be kept empty and as dry as possible, all openings being closed to prevent access of air and thus retard corrosion.

If the boiler is of such a type that it cannot be completely drained, it may be dried out by using a very light wood fire or large lamp, at the same time raising the safety valve and noting when vapor ceases to come off. In cold weather the engines, pumps, pipes and condenser must also be kept drained. It is well to provide tarpaulins for engines and boilers, putting them on in wet weather and removing them promptly when the weather clears. Launch machinery being out of sight when the boat is at the davits, it is apt to be neglected in this as well as in other respects. At sea it is preferable to cover the polished steel-work of launch machinery with a mixture of white lead and tallow instead of the thin coat of oil, as in stormy weather it is often difficult to clean the machinery, and salt spray washes off the oil.

The officer in charge of a launch will find it convenient to keep for reference a memorandum of the size and weight of the boat, the type, weight and number or other distinguishing marks of engines, boilers and pumps, a list of necessary tools, stores, amount of coal, water and oil usually carried, the maximum speed of the boat and revolutions of engine, the steaming radius, amount of extra coal, water and oil required to cover a given distance at the desired speed, the allowable steam pressure, the usual vacuum attainable when all parts are in good order, and the greatest number of passengers the boat can carry. This data will be found convenient when about to order stores or spare parts, when instructing a new crew, or fitting out for a long trip.

CHAPTER X.

HANDLING BOATS IN A SURF.

§ I. PRELIMINARY.

The handling of boats in a surf is an art in itself, calling for special knowledge and skill such as can be acquired only by practical experience. When undertaken by those who have not this experience, the danger involved can hardly be over-estimated.

Of the various methods of landing on a flat beach which are described in the Rules of the National Life-boat Association quoted below, the safest is probably that of backing in, keeping the bow toward the surf, pulling out to meet each breaker, then backing in as fast and as far as possible *on its back.*

A surf never looks as dangerous when seen from seaward as it really is; and a boat having to land through it, should, if there is a possibility of help from the shore, await such help before attempting to go in. As, however, it is often necessary to attempt a landing where no expert assistance is available, the following rules have been drawn up and published by the Royal National Life-boat Institution of Great Britain:

§ II. RULES PUBLISHED BY THE ROYAL NATIONAL LIFEBOAT INSTITUTION, ON THE MANAGEMENT OF OPEN ROWING BOATS IN A SURF; BEACHING THEM, ETC.

In Rowing to Seaward.

As a general rule, speed must be given to a boat rowing against a heavy surf.

Indeed, under some circumstances, her safety will depend on the utmost possible speed being attained on meeting a sea.

For, if the sea be really heavy, and the wind blowing a hard on-shore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an approaching heavy sea may carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case, is to obtain such way as shall enable her to pass end-on, through the crest of the sea, and leave it as soon as possible behind her. Of course if there be a rather heavy surf, but no wind, or the wind off shore, and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it, that her bow would fall more suddenly and heavily after topping the sea, than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such a character, that there may be chance of the former carrying her back before it, that full speed should be given to her.

It may also happen that, by careful management under such circumstances, a boat may be made to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent her being carried back by a surf, her way may be checked on its approach, which will give her an easier passage over it.

On Running before a Broken Sea, or Surf, to the Shore.

The one great danger, when running before a broken sea, is that of *broaching-to.* To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to, when running before a broken sea or surf, is, that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the effect of a surf or roller, on its overtaking her, is to throw up the stern, and as a consequence to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat, on being overtaken by a heavy surf, has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air and the wave carries the boat before it on its front or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water, being stationary or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern, or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-steerage, run a considerable distance until the wave has broken and expended itself. But it will often happen, that if the bow be low, it will be driven under water, when the buoyancy being lost forward, whilst the sea presses on the stern, the boat will be thrown (as it is termed) end-over-end; or if the bow be high, or it be protected, as in most lifeboats, by a bow air-chamber, so that it does not become submerged, that the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea and be thrown by it on her beam-ends, or altogether capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land, after being compelled to desert their vessels.

Hence it follows that the management of a boat, when landing through a heavy surf, must, as far as possible, be assimilated to that when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enabling it to pass her. There are different ways of effecting this object:

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy, and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf, than by backing them only.

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practised in some lifeboats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket, or canvas bag termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and to prevent her being turned broadside to the sea or broaching-to.

Drogues are in common use by the boatmen on the Norfolk coast; they are conical-shaped bags of about the same form and proportionate length and breadth as a candle extinguisher, about two feet wide at the mouth and four and a half feet long. They are towed with the mouth foremost by a stout rope, a small line, termed a tripping line, being fast to the apex or pointed end. When towed with the mouth foremost, they fill with water, and offer a considerable resistance, thereby holding back the stern; by letting go the stouter rope and retaining the smaller line, their position is reversed, when they collapse, and can be readily hauled into the boat.

Drogues are chiefly used in sailing-boats, when they both serve to check a boat's way and to keep her end on to the sea. They are, however, a great source of safety in rowing-boats, and the rowing lifeboats of the National Lifeboat Institution are now all provided with them.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled or let go, will act in some measure as a drogue, and will tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea the best trim is deepest by the stern, which prevents the stern being readily thrown on one side by the sea.

A boat should be steered by an oar over the stern, or on one quarter when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships on a sea breaking over the stern.

The following general rules may therefore be depended on when running before, or attempting to land, through a heavy surf or broken water:

1. As far as possible avoid each sea by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, and especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or any other instrument in the boat that may be used as one, tow it astern to aid in keeping the boat end-on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat towards the end that is to seaward, but not to the extreme end.

5. If a boat, worked by both sails and oars, be running under sail for the land through a heavy sea, her crew should, under all circumstances, unless the beach be quite steep, take down her masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she has sails only, her sails should be much reduced, a half-lowered foresail or other small head-sail being sufficient.

Beaching or Landing through a Surf.

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water, on a flat shore, where the waves break in three or four fathoms water, is the heaviest, and therefore the most dangerous, and when it has been passed through in safety, the danger lessens as the water shoals, until, on nearing the land, its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats on landing different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her further in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach, it is the general practice, in a boat of any size, to retain speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round towards the direction from which the surf is running, so that she may be thrown on her broadside up the beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations, we believe, it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

§ III. NOTES ON THE MANAGEMENT OF BOATS IN A SURF.[1]

From the ship a mile or two off shore, the surf may seem uniform, with no sign of a choice for making a landing. Looking at the backs of the breakers, as to leeward over the waves at sea, gives an inadequate idea of their height and abruptness. In fact, what appears to be a mere swash on the beach, may involve much danger to a carelessly handled or deeply-laden boat. Careful study will often give hints of important differences in the nature of the coast.

There may be stretches of sand beach backed by trees, the lights and shadows of which, according to their relative distances, indicate low-lying points, shallow bays, sand-choked river mouths, or even the lateral entrance of a lagoon into which the ship herself may safely pass. There may be bluffs, below which doubtless lie rocks, sometimes only shown in the churned-up surf when dangerously near. There is often a current along the shore, and this should be studied before attempting to land. Sometimes its direction changes with the tide; again it is of the nature and perhaps part of an ocean current flowing constantly in one direction. Where there are cliffs, their débris is often swept into the form of an irregular breakwater towards the lee side. This shoal, being of varying height and lacking continuity, may be of little help when covered by high water, but at low water it sometimes affords all the lee required to make an easy landing.

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[1] By Lieutenant A. A. Ackerman, United States Navy.

Narrow cañons in long stretches of bluffs, or pockets in a rocky coast, sometimes mark quiet spots; the swell flowing in through deep water and breaking directly on the beach. Such places should as a rule be avoided until carefully studied. It may be possible to make use of them to land behind detached rocks or pass behind the breakers of the adjacent bluffs, but there are always sunken rocks to be feared; and the fall of the tide, or the setting in of a heavier swell, may suddenly turn the smooth seas at the entrance into heavy breakers.

A single rock, hardly far enough off shore to be shown on the chart as separated from the beach, will frequently have a quiet place in its lee, although the approach to it may at times be dangerous.

It is more difficult to choose a landing on a long stretch of sand beach; but wherever a shoal appears, or the surf stretches far out, a comparatively light surf, and perhaps even a smooth way in, should be looked for on the lee side.

Confused surf off the mouth of a lagoon or river, or the slanting breakers which sometimes run along the beach, as a rule indicate strong currents. When these are understood, a handy boat may sometimes dodge the breakers and work into smooth water with surprising ease. There is always danger, however, that the stranger may be swept down into heavy surf, or while heading up against the current or main breakers, have the boat filled by cross-seas.

Often a number of the heaviest swells follow each other in succession, after which there is a short and comparatively mild interval. Such a recurrence of quiet spells, as well as the point at which the swells become dangerous by commencing to break, and that at which they fall into harmless confusion, should be watched for and taken advantage of in landing.

The number of lines of breakers or width of surf does not always determine the difficulty of landing, as the outer lines will be much the heaviest; and if these can be avoided or passed without shipping too much water, the others will probably not be dangerous to a well-handled boat. Notice should always be taken before entering the surf, especially where it is wide, of the probable drift of the boat. It may be set by the current down among rocks or into heavy breakers.

The beach, too, may present obstacles to a safe landing, apart from the surf. At high water, it may break directly on a steep shingle beach which would be difficult to climb, even without being obliged to drag the boat clear of the breakers. If assistance could be had from on shore, such a beach might be charged on the back of a breaker and the boat hauled up clear before the next one filled it. Working with the crew alone, however, the depth of water and poor foothold would usually prevent any but the most active crew in a light boat from landing without being swamped. At the same point, an easy landing might be made on the sloping sand beach below the shingle by waiting an hour or two for lower water.

Before entering the surf at a strange locality, it is well to lie off it for awhile, noting its peculiarities and accustoming the crew to them. Dangerous breakers may form and pass, but the quieter intervals are very encouraging.

Speaking generally, a very light and buoyant boat, with a crew of as small a number as possible to handle it, will pass in and out through moderate surf with ease, while a heavy ship's boat with a powerful crew would at least take on board considerable water. Beyond a certain point, the added strength of a man does not begin to compensate for the increased weight. The requirements of a good surf-boat differ materially from those of a deep-sea life-boat, yet they are alike in some particulars. The difference lies mainly in the fact that the latter is designed to ride in a rough sea, which, since the boat rises and falls with it, does not have the battering force of a breaker. The surf-boat, on the other hand, perhaps while lying dead in the water, or carried out by oars and undertow, must meet and pierce or surmount a wall of water advancing with great velocity.

A very light and broad-beamed, single-banked, six-oared whale-boat is perhaps the type of ship's boat in which the best proportion of power to resistance and weight moved is likely to be obtained.

If time permits, a towing-post should be fitted in the bow for veering the surf-line and this may be suddenly required to take great strain when the boat is struck by a breaker.

Besides possessing the buoyancy due to lightness of material, it would be a great advantage for the boat to be fitted with light air-tanks filling all unoccupied space and so reducing to a minimum the capacity for shipping and holding water. In fact, an extreme type of surf-boat would somewhat resemble the Esquimo's kayak, in which the boat has a cover, the only opening of which is gathered tightly around the occupant's waist.

Great *sheer* is important, and the upper strakes should flare somewhat at bow and stern to prevent their dipping under when the opposite end of the boat is lifted high on the side of a breaker. The flare of upper strakes, however, should not amount to such bluffness as will increase resistance to cutting through the crest of a wave. To permit the boat to rise and fall quickly in response to the swell, weights should be kept out of the extreme ends.

The underwater body of the boat should offer as little lateral resistance as possible to the water. Should she, in pulling out to meet a breaker, be inclined slightly from the normal and be carried back, however little, her keel, rudder-post and run would be resisted and retarded by the dead water on the front of the breaker, while the bow would be swept rapidly around turning the boat more and more broadside on, until the gunwale dips and it finally rolls over. The coxswain must in such a case attempt to pry the stern around with his steering-oar and the crew make every effort to get way on the boat and surmount the breaker before the turning action has culminated in a capsize. If the bottom of the boat is rounded and smoothed off in every direction, the water has very little hold either for turning it against the leverage of the steering-oar, or to roll the boat over should it broach-to. In fact, a light dory has been known to be swept broadside on for a long distance before a breaker without capsizing. The smooth bottom offered so little resistance to the dead water on the shore side of the breaker that there was very little tendency to trip the boat up.

High freeboard, high roomy thwarts and favorable positions for oarsmen and coxswain to exert their strength, are all important qualities. The modern navy whale-boat is a great improvement over the old one in these respects. It is, however, necessarily a compromise; and with very little alteration it could be greatly improved for passing the surf. Its propelling power should be nearly equally spaced about the center of buoyancy, which may be accomplished by placing an additional thwart in the stern sheets and leaving the forward thwart vacant. Passengers should sit on the bottom of the boat between thwarts; all unnecessary weights and gear should be removed. The coxswain should have a grating lashed over the stern sheet benches to give him a good foothold. Swivel rowlocks should be used; there is great danger of fouling the oars in the surf and it would then be very difficult to free one from an inserted rowlock before it had caused the boat to broach-to. Stretchers and boat-breakers should be lashed down and all other unnecessary gear dispensed with.

The subject of oars merits consideration. The steering-oar should be broad, stiff and not too long. Its exact length depends upon the boat and the height of the coxswain's platform; eighteen feet may be regarded ordinarily as a good length. A longer oar may be used to advantage at sea and its need may be felt at times in the surf; for example, when the stern is raised on the crest of a breaker and the blade of the oar barely reaches the water in the trough. On the other hand, when the boat is in a dangerous position and being carried back, a long oar is worse than useless, as it is almost impossible to keep its blade from catching in the dead water, where it tends to turn her broadside on. The other oars should also be light and stiff to permit easy handling and quick application of power. On troubled water, either at sea or in the surf, oars which exceed a certain length dependent upon the beam and freeboard of the boat are a nuisance. They cannot be handled quickly, wear the men out and are certain to strike on the back stroke or foul each other. If, in addition, they are springy, by the time the power is well applied in one direction, the boat may be turned or tilted and most of the stroke lost. No hard and fast rule can be given for the length of oars; that had better be determined by actual test in each particular boat. It will seldom, if ever, however, be found advisable to employ in a single banked boat, an oar longer than twice the beam at the thwart plus the freeboard at the oarlock.

Whichever way of landing is adopted, a conical drag, towed ten to twenty fathoms astern, will be of great assistance. It should have a tripping line to invert it when it is not required to check the boat. Too much reliance should not be placed upon the drag, however, for though it will always *assist* to keep the boat pointed fair to the breakers when the line is hauled in briskly by a couple of men, there is not the positive assurance of holding the boat that is given by a surf-line attached to a well-bedded anchor planted outside the surf.

There are occasions when the use of such a surf-line and anchor is invaluable. Among them may be noted the landing in a large or unwieldly boat; landing with a weak or inexperienced crew, or in high surf where it is necessary to return, or in any case where it seems pretty certain that the crew will be unable to maintain control over the boat with their oars. On the other hand there are certain disadvantages connected with the use of the surf-line. There is a current along almost every beach and if the surf is wide, a boat going out may drift down so far that when the dangerous breakers are reached, the line to the anchor leads broad off the bow and tends to turn the boat rather than steady it head-on to the breakers. Should a boat using a surf-line be capsized in the outer surf, the coils of line will probably knot and tangle so as to prevent the boat from drifting in.

Whenever the line is used, a hatchet should be kept close to the bowman's hand with which to cut the line should it become necessary. In going in where the surf is wide or there is a current, the line may be used to pass the outer breakers and then abandoned. If a bucket is tied to the end, it may be picked up again and used on going out. The anchor should be buoyed with spare oars or other gear so as to recover it should the boat be obliged to abandon the line or to cut it in coming out.

All unnecessary articles are taken out of the boat. The water-breaker is tightly plugged and lashed down, as are the stretchers and buckets for bailing. The men shift into light clothes without shoes. If the weather is sufficiently cold to require it, dry clothing may be carried in the air-tanks, which should, however, be carefully inspected and all unnecessary articles removed. A hatchet, copper tacks, sheet lead, and roll of felting should also be carried for use in case the boat is stove. If the beach is distant, it may be possible to go under sail, or to be towed by another boat so as to keep the men fresh. The presence of a second boat would also be of great assistance, if it was used to distribute oil over the water abreast the landing, for although the quieting effect of oil is much less marked upon a surf than upon deep sea waves, there is abundant evidence that its value is considerable, especially in the comparatively deep water where the outer and most dangerous breakers form.

A second boat lying outside would be an encouragement to a crew pulling out from shore, and might be of great assistance to the probably exhausted men after their trip through the breakers.

In going out, the time of start, though important, is less so than when coming in, as it may be possible to pull half-way out without taking water on board or meeting dangerous surf. If a surf-line is used, take the boat up the beach until it appears that when carried down by the current and hauled out at the same time it will reach the dangerous space with the line fair to the anchor. Station two active, powerful men to haul in the line, as more progress will be made in this way than if they took oars. The four after-oarsmen steady the boat, standing in the water opposite their thwarts, oars apeak. Put the passengers aboard, haul taut the line, and commence walking out the boat, the coxswain at the stern. As soon as the boat leaves the bottom the men climb in and take their oars, pointing them to prevent drift until ready to start. The intention is to so time the arrival of the boat at the outer line that no heavy breakers will be met at that point. Varying width of surf and speed of boat may make this difficult of attainment.

At the start the men, pulling and hauling, force the boat rapidly through the water. Irregular waves splash into the boat; later they become too large to be pulled through without taking much water on board. It is then best to check headway, tauten the line, and peak oars as the breaker passes. So the boat works out, obviously passing many more breakers than when coming in. Gradually the filling boat becomes sluggish, difficult to pull and steer. In this condition it may be capsized if only slightly turned, and it may now be better to go back, bail out, and try again, than to struggle on and risk an almost certain capsize in the heavier breakers.

A properly pointed boat may succeed in passing through a breaker that it cannot hope to ride. The water may fill it to the thwarts, in which condition it will capsize at a touch, but once clear of the breakers it may be bailed out and enabled to meet the waves of any ordinary sea in safety.

CHAPTER XI.

GROUND TACKLE.

§ I. ANCHORS.

The form of anchor commonly used throughout the world from the beginning of the present century up to about 1875 was, in most essentials, that shown in Plate **67**. It is true that double-fluked anchors resembling those now so familiar were proposed as early as 1850, but they were slow in making their way, and it was not until about the year above-named that they began to come into anything like general use; and even now they are looked upon with disfavor by many seamen, who, while recognizing their convenience, are doubtful about their holding power.

When an old-fashioned anchor is let go in water fairly deep, it strikes the bottom crown first, and immediately falls over until it rests on the end of the stock, the arms lying horizontally. From this position any drag of the chain to one side capsizes or "cants" it, pulling the stock down horizontally upon the bottom and pointing one of the flukes fair for biting. As the drag continues, the fluke is forced into the ground, and if the anchor is well designed, the heavier the pull the deeper the fluke goes down —provided sufficient length of chain is given to keep the pull approximately parallel to the bottom. For this reason, quite as much as because of the "catenary" that comes from a long scope, it is important to use plenty of chain, particularly when the anchor is taking the first hold. In good holding ground, anchors frequently bury themselves completely. This tendency of the old-fashioned anchor to work into the ground under a pull is one of its most valuable characteristics, and one not possessed by any of the double-fluked types.

It is a common mistake to think of the holding power of an anchor as due entirely to the area of the palm. If this were the case, the merits of an anchor might be determined very simply. But the fact is that a large palm may be an actual disadvantage. No doubt the cross-sectional area of that part of the anchor which is buried has much to do with the resistance, but so has the friction of the whole surface upon the soil by which it is surrounded and which tends to pack around it and press in upon it from all sides.

If, now, an anchor drags—and it usually does so slightly in the act of taking hold—an excessively large palm breaks up the ground through which it moves and carries the soil along, leaving a broad furrow behind through which the arms and crown move without resistance. A small and well designed palm, on the other hand, permits a *flow* of the soil, which closes in behind and keeps a constant friction on the other parts of the anchor. Another disadvantage of a large palm is in its tendency to become "shod" in a clayey soil. Such a soil sticks to all parts of the anchor, but especially to the palm; and if the anchor starts after having once held, it carries along with it a shapeless mass of mud which is for the time being a part of the anchor. This adds to its weight, but does away with all chance of its biting again, and there is nothing to do in such a case but to pick up the anchor and let go another.

In the double-fluked type the palms are always large, and this type trusts for holding to their area alone. Moreover, the arms are necessarily straight—or nearly so—and lack the tendency to work downward which is so important a feature of the older form. The whole character of this anchor favors its becoming shod, and in a sticky soil it can never be trusted after it has once started.

The anchor shown in Plate **67**, represents fairly well the most approved design of the old type. The palm is of medium size, the arms shaped to the angles most favorable for biting, and the cross-section of each part carefully designed for maximum strength in the direction of the strain to which it will be subjected. All edges are chamfered off to reduce the wearing of the chain as its bight rides over the anchor, and all re-entering angles are rounded as much as possible.

While double-fluked anchors are not necessarily stockless, most of those in use are so, and claim this feature as a merit. It certainly adds greatly to the convenience of handling and stowing, and this is the ground on which the patent anchor makes its strongest appeal for favor; but so far as holding is concerned, it is unquestionably a disadvantage. As a ship swings around her anchor, there are many times when the chain leads off to one

Plate No. 67.

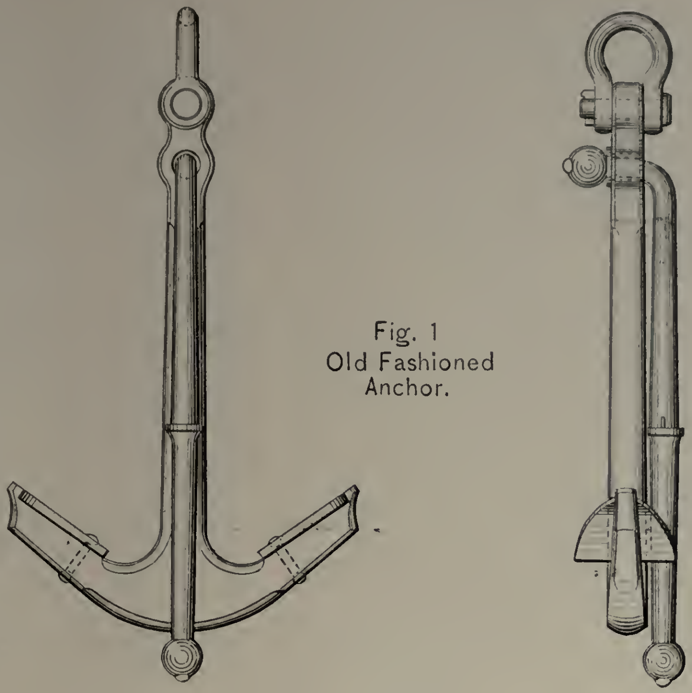


Fig. 1
Old Fashioned
Anchor.

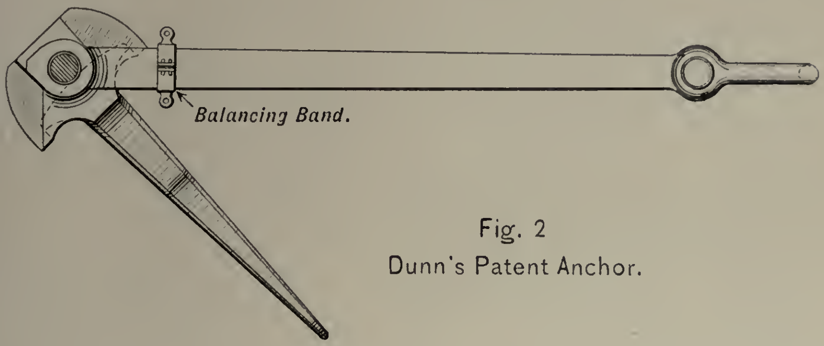
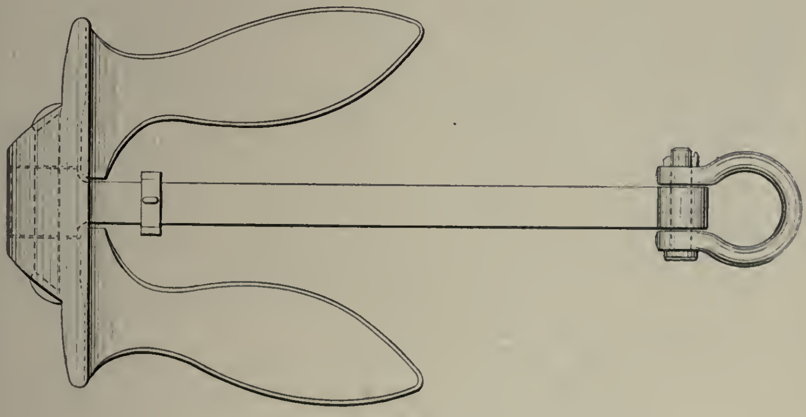


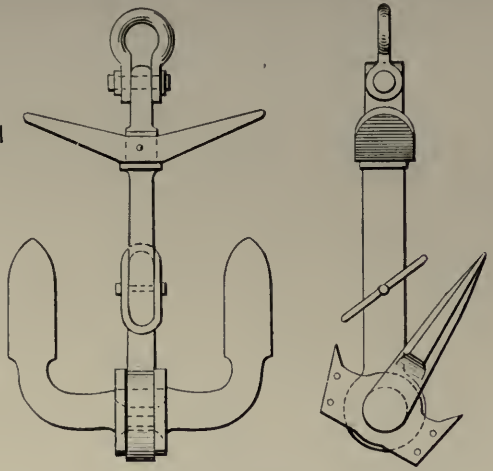
Fig. 2
Dunn's Patent Anchor.



ANCHORS, U. S. NAVY.

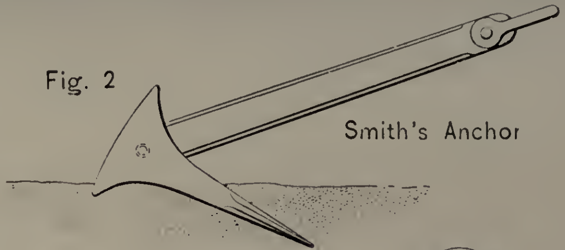
Plate No. 68.

Fig. 1



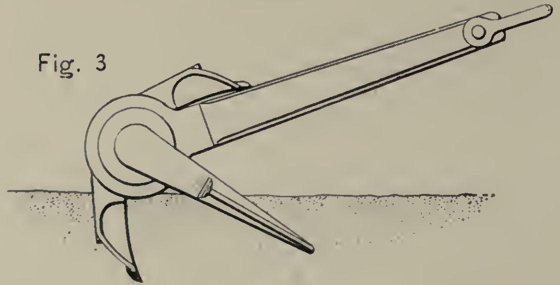
Martin's Anchor.

Fig. 2



Smith's Anchor

Fig. 3



Tyzack's Anchor.

Hall's Anchor.

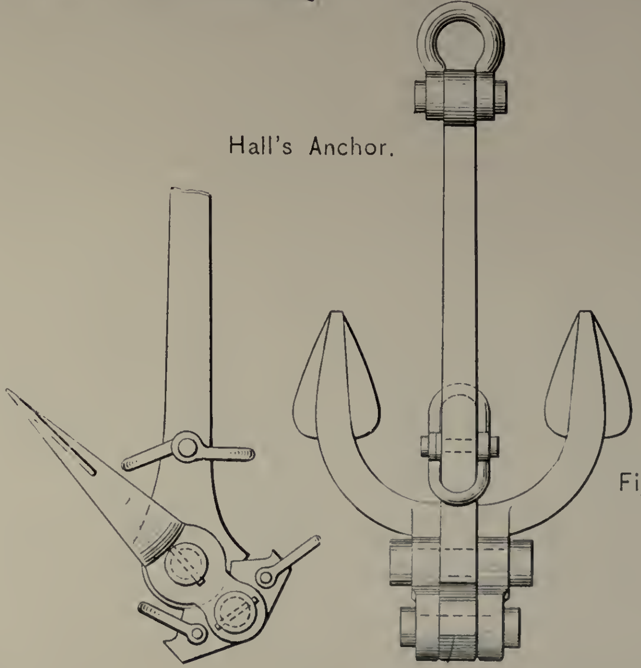


Fig. 4

ANCHORS PATENT.

side and upward with a pull upon the ring tending *to roll the anchor over* and so break out the fluke (or flukes). A similar tendency will exist in the case of a direct pull, if the flukes of a patent anchor encounter different degrees of resistance. A stock prevents rolling over under these conditions, whether with a patent anchor or an old-fashioned one, and many seamen insist that it is hardly less useful in this matter than in canting. One of the best known of the patent anchors (Martin's, Plate **68**), has a short stock as a concession to this view, and nearly all double-fluked types may be had with stocks if desired.

Plate **68** shows several of the best known types of double-fluked anchors. The following features are common to them all.

1st. The arms are pivoted upon the shank and can swing from thirty to forty degrees on either side.

2nd. The palms are in the plane of the arms instead of at right angles to it.

3rd. It results from this construction that both flukes should bite if either one does.

4th. To insure that the flukes shall bite, the arms carry, at the crown, a projecting shoulder with a sharp edge, which takes on the bottom and throws the arms downward.

They are catted and fished, if at all, at a single operation, by a pendant (or purchase) hooked into a balancing link. In many cases, they are hoisted direct to the hawse-pipe and stowed there.

TYZACK'S.—In place of a shoulder at the crown for throwing the arms downward, this anchor has a third fluke there which not only tilts the others but assists them in holding.

SMITH'S.—This type has two tilting shoulders, one at the base of each arm, instead of a single one at the crown.

HALL'S has its tilting shoulder distinct from the arms and pivoted upon them, while they in turn pivot upon the stock.

DUNN'S (Plate **67**).—This is an American type, and is much used in the United States Navy. The shank engages the arms by an enlarged head, so that its holding strength is independent of the pivoting pin. If this pin breaks, the anchor continues to hold as well as before.

Patent anchors have unquestionably very great advantages in convenience of handling and stowage. If carried on the bow, they are catted and fished in a single operation and with comparatively little trouble; they stow compactly, and have no stock or fluke projecting to interfere with the gun-fire of a man-of-war or to be a menace in case of collision. In merchant ships they are often hoisted to the hawse-pipe and the shank hauled inside, while the flukes lie close up to the side of the ship. In some cases, the hawse-pipe is made large enough to take in the whole anchor. Both of these arrangements do away with catting and fishing—an advantage which cannot fail to be appreciated by any officer who has ever had to cat and fish an old-fashioned anchor while steaming (even dead slow) into a head sea. It is, moreover, a great advantage to have the anchor always ready for letting go and to be able to drop it from the hawse-pipe instead of from the cathead, as the sudden jerk with which it brings up on the chain in the old-fashioned way not only strains the cable unnecessarily, but is apt to start it running out so fast that more or less slack chain is paid down on top of the anchor, with danger of fouling it.

Where the anchor stows at the hawse-pipe, it is let go by the mere slacking of a friction brake; the chain goes out regularly, and is always under control—a great advantage at all times and especially when anchoring in deep water.

Convenient as this arrangement is, it has one disadvantage in that the anchor may sometimes fail to start when the attempt is made to let go. This is very likely to occur if the running parts of the windlass are not kept clean and well oiled. In waters where the anchor may be wanted suddenly and where a delay in letting go might result in danger, it is well to have a few hands standing by at the hawse-pipe, with a bar to start it if necessary.

A further advantage of the patent anchor is its comparative freedom from danger of fouling. As it lies on the bottom, it presents no projecting parts, like the stock and fluke of the old-fashioned anchor, for fouling the chain. The absence of projections, moreover, does away with the danger that the ship may be bilged by grounding on her own anchor in shallow water.

In spite of the advantages above enumerated, the patent anchor cannot be regarded as fulfilling satisfactorily the ultimate purpose of an anchor if it is deficient in the power of holding a ship. This is, and must be, the final test in the matter. With regard to this point, there is a wide diversity of testimony but it may probably be asserted safely enough that in a critical situation most seamen would prefer to trust the old-fashioned anchor rather than the new one. In good stiff holding ground there is not much to choose between the two. If there is any difference here it is probably in favor of the double-fluked type. In soft mud this type is likely to drag, whereas the old style will usually work its way down until it holds. On a hard bottom, the old style has a much better chance of biting than the new one, the latter showing a disposition to skid along the ground, in spite of the tilting shoulder.

It may be laid down as a rule that the patent anchor always needs a longer scope of chain to bite and hold than does the old-fashioned one. This is because a slight upward pull on the ring drives the old-fashioned fluke into the ground but breaks out the flukes of the other type.

A double-fluked anchor with a stock combines many of the advantages of the old type and the new; and this seems likely to be the anchor of the future. Nearly all of the patent forms may now be had with stocks if so desired. The stock is in all cases short, and placed in the plane of the flukes. It is curved to let the chain slip off in case of fouling.

Nearly all merchant vessels have long used patent anchors, and they are now adopted either exclusively or in part by all important naval services.

There is an important difference between men-of-war and merchantmen which explains in a measure the greater willingness of the latter to adopt the patent anchor. Men-of-war frequently lie at anchor in exposed roadsteads for long periods of time, and need, above all things else, an anchor which will hold.

Merchant steamers in three cases out of four tie up to a dock, and when they anchor, it is usually for a few hours only, during which time they always have steam available.

Anchors are now usually made of either forged or cast steel, recent improvements in the manufacture of the latter metal having made it sufficiently reliable to justify its employment for this purpose. But the stock, rings, pins, shackles, balancing bands and other fittings should in all cases be forged.

§ II. CHAIN CABLES.

Chain cables are made from bars of wrought iron, each link being cut to the proper length, with ends bevelled, and shaped upon a mandrel to the form of Fig. 3, Plate **69**. The ends are left open to admit of threading the new link through one of those already made; and the width is left a little greater than the finished shape, to give space for fitting in the stud. The link having been slipped into its place, the ends are forged together, and the studs inserted. The studs are of cast iron and are held in place by the pressure with which the link, in cooling, closes in upon them, forming the finished link shown in the plate.

The principal use of the studs is to prevent kinking. It has been maintained by many authorities that they add to the strength of the link and by others that they weaken it, but careful experiments at the Boston Navy Yard covering many years show that they affect the strength very little, if at all, whatever effect they have being to weaken the link rather than to strengthen it.

Chain is designated as to size by the diameter of the iron of which it is made, standard sizes running by sixteenths of an inch from ¼ inch upward. The largest size issued to ships is about 2½ inches.

SHACKLES.—Chain is usually manufactured in lengths of 12½ fathoms (English) or 15 fathoms (American) and the lengths are connected by shackles (Plate **69**), the round end of the shackle being always turned toward the anchor. This enables the wildcat to engage it properly, and prevents danger of catching on the controller and the hawse-pipe as it runs out.

The bolt of the shackle is oval in section and tapered slightly from the head toward the end. It is held in place by a pin, usually of steel, driven into a hole passing through the bolt and the enlarged ends of the shackle.

In the best English practice, the hole for the pin is reamed out at each end, and a lead pellet driven in and upset, to hold the pin securely (Fig. 9, Plate **69**).

In the American practice, the pin is made sometimes of soft iron and sometimes of wood—preferably hickory—well coated with white lead and driven in tightly (Fig. 8, Plate **69**). If these pins cannot be backed out, they may be sheared by a few smart taps of a hammer on the end of the bolt.

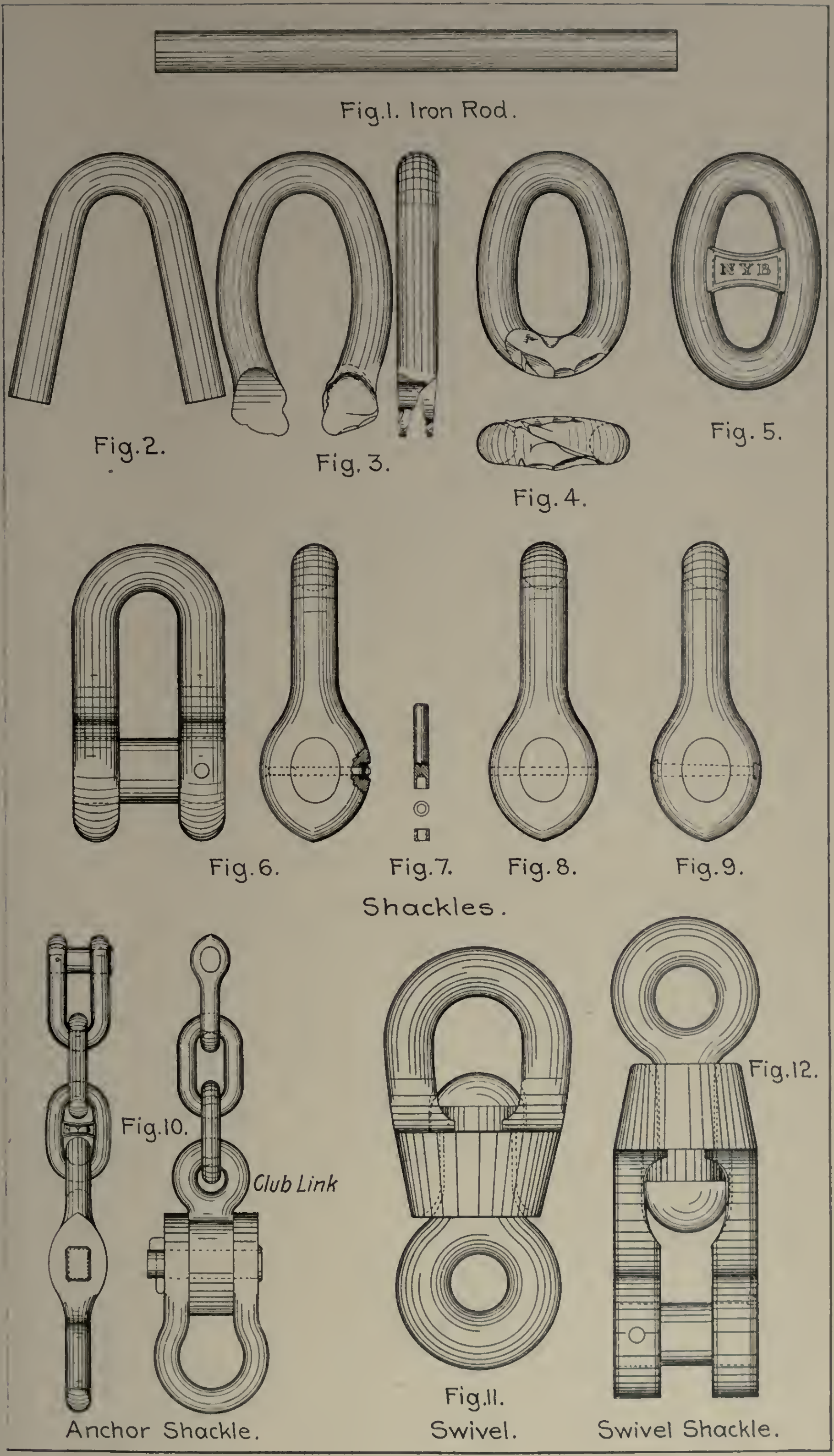
Iron pins should be tinned.

The latest practice in the United States Navy is to use a steel pin and a soft lead ring, which is upset, by a special tool, into a groove around the end of the pin (Fig. 6, Plate **69**).

In unshackling, this ring is sheared.

To admit of slipping the shackle into place, the end links of

Plate No. 69.



PARTS OF CHAIN CABLE, U.S. NAVY.

each length of chain are made without studs and of dimensions corresponding to the next larger size of chain.

SWIVELS.—To prevent the accumulation of turns as the ship swings about her anchor, swivels are used (Plate **69**). Formerly there was one of these in every length of chain, but they gave much trouble in passing around the capstan (being too large to take the sprockets), and their number has been gradually reduced until now not more than three or four are used in the cable, and often only two—one in the first and one in the last length.

There has been lately adopted for use in the United States Navy, a "swivel-shackle" shown in Plate **69**, which is, as the name indicates, a combination of these two parts in one. This is used at about 5 fathoms from the anchor. Swivels of the ordinary type are used at 52½ and 97½ fathoms.

LENGTH OF A CABLE.[1]—The total length of a cable may be anywhere from 90 to 200 fathoms. In the United States Navy the standard length is 120 fathoms, but more is sometimes used for large ships. In the English Navy the length varies with the size of the vessel, 200 fathoms being used for the bower cables of a battleship. In the merchant service (English), the total length of chain to be carried by ships of different tonnage is prescribed by law, as is also the size; but there is no requirement with regard to the length which shall be used on one cable.[2]

STOWAGE.—The cables are stowed in "chain lockers" which are usually in the hold, below and a little abaft the windlass. As the chain is paid down, it is stowed clear for running out, by men called "tierers." The inner, or "bitter" end of the cable is first of all brought up from the locker and made fast to a beam or other accessible place by some method which, while holding securely, shall admit of easy slipping, or of bending on an additional length. In merchant vessels, the bitter ends of the two bower cables are sometimes shackled together. This is a bad practice, as it leads to delay and difficulty when an additional length is needed on either cable.

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[1] A "Cable's Length" as a unit of measurement is always 100 fathoms.

[2] American laws do not deal to any important extent with the details of equipment of merchant vessels. English laws, on the contrary are very full in connection with such matters, and "Lloyd's" requirements, which in the commercial world have all the force of law, cover every conceivable detail of construction and outfit.

Bending the Cable.—The chain is bent to the ring of the anchor by a shackle similar to the shackle used between the lengths of the cable, but somewhat larger. Its details, as well as those of the links immediately adjoining it, vary considerably. Plate **69** shows the method used in the United States Navy. The club link, which is interposed between the anchor shackle and the end link of the cable, fits snugly upon the bolt and gives a good bearing both to the bolt (through its full length) and to the sides of the shackle. As a matter of convenience, the anchor shackle, club link, and three other links, forming a "triplet," are left permanently attached to the anchor, and the cable connected to this triplet by a regular connecting shackle. This does away with the inconvenience of handling the heavy anchor shackle in bending and unbending chain.

Marking.—Cables are marked by turns of wire on the studs of certain links, the number of the link, counting from the shackle on each side, indicating the length. Thus at the end of the first length from the anchor there is *one* turn of wire on the stud of the *first* studded link from the shackle on each side; at the end of the second length, *two* turns on the *second* studded link, etc.

In many cases a single turn of wire is used at each shackle, the number of the link being considered sufficient to indicate the length.

In the United States Navy, shackles are marked in manufacture with a number cut into one side of the eye, indicating the position of the shackle from the anchor. As these may become caked with mud, they do not take the place of the marks above described.

Overhauling a Cable.—Cables should be overhauled frequently, the chain being roused up on deck, and each shackle, link and swivel carefully examined. Flaws may be detected by the ring of the metal when struck with a hammer. A defective shackle may be easily replaced by a spare one, but a bad link condemns the whole length of chain in which it occurs—except that a missing stud may be replaced without much difficulty. Every length should be unshackled, and shackle bolts and pins cleaned and coated with white lead and tallow. If a pin is found rusted in, the rust may be cut with turpentine, or the pin broken. Swivels should be well oiled, and worked until they turn freely and without grinding. All marks should be verified, and renewed if necessary.

The chain-lockers having been cleaned and painted, the chain is paid below and carefully stowed, the bitter end made fast and the anchor end shackled to the triplet.

One of the most frequent and serious accidents to which cables are subject is the springing of a shackle by a strain tending to open out the ends.

Such a strain may come from a bad fit on the windlass in heavy heaving, or from the accident of the shackle being subjected to a heavy stress while lying across the outer lip of the hawse-pipe. A pin may be broken in some such way as this, and the bolt loosened, without the injury becoming apparent on casual inspection.

It is a good rule to have each shackle carefully examined as it comes in, every time that the anchor is weighed.

The details of chain cables as now manufactured for the United States Navy are shown in Plate **69**.

The "Swivel Shackle" there shown is intended to be placed at 5 fathoms from the anchor, but if the distance from the hawse-pipe to the windlass, or from the hawse-pipe to the anchor as it lies on the bill-board, is less than 5 fathoms (and it usually is so), the swivel-shackle is placed as much nearer to the anchor as may be necessary to insure that it shall never come to the windlass, nor be inside the hawse when the anchor is let go.

The chain as now issued is in seven lengths, or "shots," the first shot being of 5 fathoms, *the second of 40*, the others of 15 each. As there is neither a shackle nor a swivel between 5 fathoms and 45, there is no danger that either of these will be on the wildcat in breaking ground; and the cases will be rare in which they come to the wildcat at all.

All chains for the naval service are made at the Boston Navy Yard. The process of manufacture is as follows:

After the iron is rolled into the finished bar, it is sheared into the neat length for making a link of chain, and a number of these lengths are kept in the chain fires for the purpose of gradually becoming heated.

The makers of the chain consist of one chain maker and a number of helpers, depending upon the size of the chain.

Ordinarily they begin with the end link. If, however, it is a swivel shot that is to be made, they begin with the swivel and work both ways.

In England, the weld of the link is almost invariably on the side. In the United States it is almost invariably made at the end. The advantage of an end weld is that the metal at the scarf is gripped by the adjoining link, whereas in the side weld nothing of this kind occurs.

In forming a link, it is first bent to a form between a V and a U. The ends are then turned over toward each other, forming, in the rough, an oval with the ends open sufficiently wide to be threaded in the next link.

It is then put in the fire for a good heat. The next operation is to form the scarf, which is done, in a 2½" chain, by two men using the peen and one the flat, of heavy sledges; the chain-maker, assisted by a helper, holding the link in position. When the scarfs are formed they are closed together and flattened down to the rough form of a link, all ready to receive the welding heat. Usually in a large chain two heats are required to make a perfect weld and to dolly the weld into smooth and regular form. The link at this time is a little wider and a trifle shorter than it will ultimately become. This is to admit of placing the stud, which is of cast-iron or drop-forging, between the two sides of the link, and then closing it down. This stud is not welded to the metal of the link in any way, but is only held there by the compression of the sides.

In handling the chain before the fires, it is always suspended from the roof of the shop, the working end being so that it just clears the ground. This allows it to be put in the fire and to reach the anvil without difficulty. At some time during the operation of manufacturing each shot of chain, an order is given to cut out three links from those last made, for testing. These are broken in the testing machine, the capacity of which is 600,000 pounds. It is a rare circumstance when one fails to come up to the requirements and generally the breaks are from 10 to 20 per cent above. Upon the completion of a shot its total length is somewhat shorter than ninety (90) feet, for in giving it proof strain there is considerable stretch. When the chain is put in the testing pit, every link is placed so that its pull on its neighbor is exactly true. This is in order that the links shall not be deformed under their first strain.

The following table shows the breaking and proof strains in pounds for the sizes given:

Size.	Breaking Strain.	Proof Strain.
1¼"	106,761	56,700
1½"	154,266	81,000
1¾"	206,281	109,200
2 "	266,971	140,300
2¼"	330,882	176,400
2½"	391,186	220,000

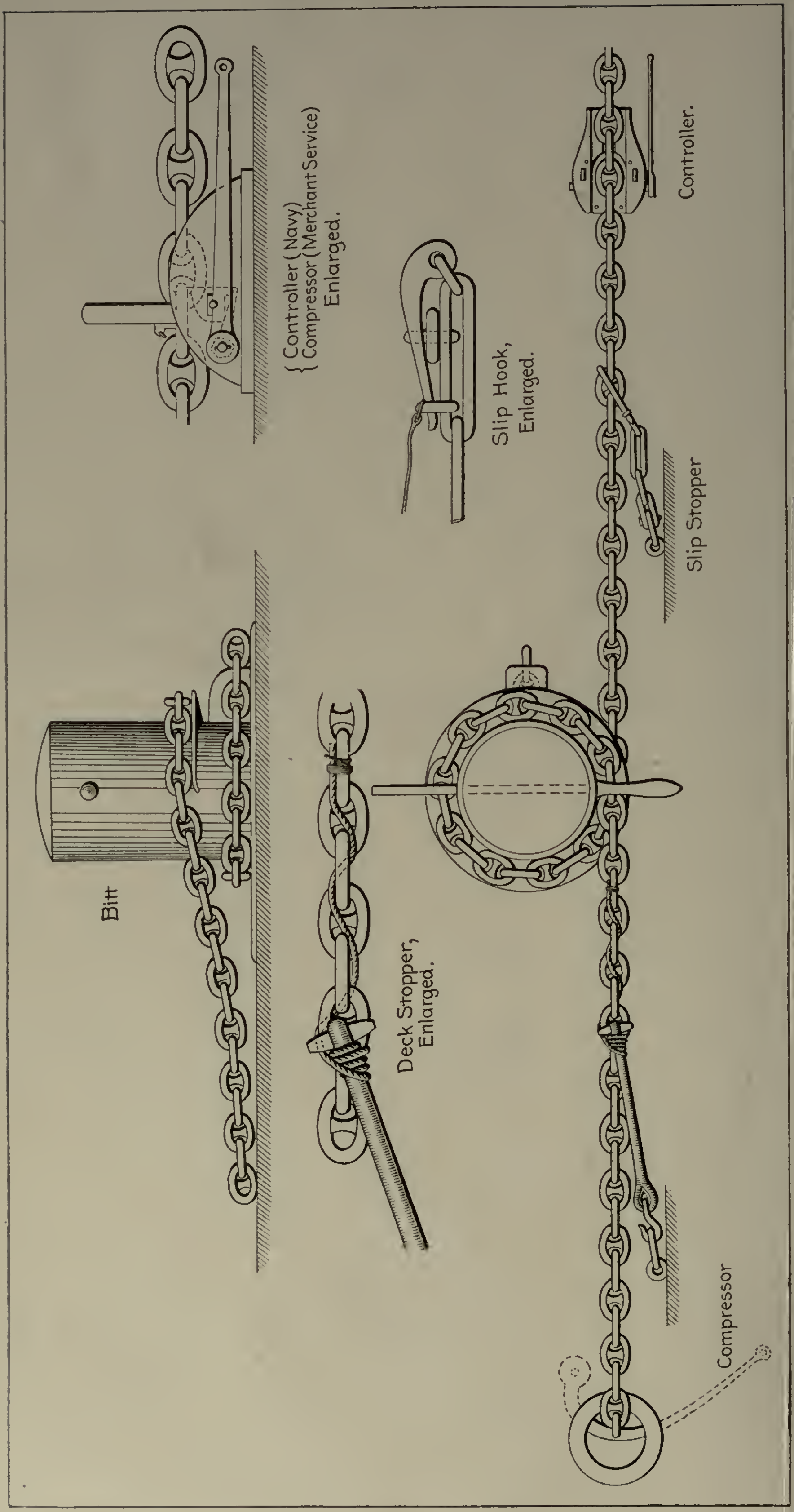
The "proof" strain to which the whole chain is subject is 45 per cent of the "breaking" strain, the latter being applied only to the three links that have been removed from the chain for this purpose.

§ III. CAPSTANS, WINDLASSES, ETC.

CAPSTANS.

Strictly speaking, a capstan differs from a windlass in that its axis is vertical while that of a windlass is horizontal. The terms are, however, often confounded; and there is a tendency of late to call everything a windlass which is fitted with sprockets for engaging the links of a chain, and everything a capstan which

Plate No. 70.



GROUND TACKLE.

takes a rope around a barrel. Thus we hear of "horizontal capstans" and "vertical windlasses."

Most of the modern contrivances for weighing anchor have horizontal shafts and are therefore properly windlasses. The old-fashioned capstan is, however, still in use in many ships, though probably not in any of recent construction. It can be used with either rope or chain, the chain being engaged by sprockets at the base of the shaft, and the rope being taken around the barrel. It can be worked either by steam or by manual power.

The chain is entirely clear of this capstan except when "brought-to" for heaving in. At other times, it leads along the deck from the chain-pipe to the hawse, with a turn around the bitt. In riding, it is further secured by one or more stoppers and by the compressor.

A COMPRESSOR (Plate **70**) is a curved arm of iron, which sweeps across the mouth of the chain-pipe below the deck, choking the chain in against the lower edge of the pipe. It is pivoted at one end and has an eye in the other to which a tackle hooks. It is used to check the chain after letting go the anchor, and must be strong enough to stand a heavy shock in doing this, and to hold the ship until stoppers can be passed; also to check and hold the chain in veering.

DECK STOPPERS (Plate **70**) are used to hold the chain when the anchor is down. They are best used abaft the bitts, as then they are assisted by the bitts in holding; but for bitting and unbitting they must be used forward.

To pass a deck stopper, it is laid along the chain, inboard, and the lanyard is passed over and under, working aft, until several turns have been taken, when it is led forward, wrapped around the chain and stopped down. The stopper having been secured, the compressor is hove back to let the stopper take the strain, and then again hauled to.

SLIP STOPPERS (Plate **70**) may conveniently take the place of deck stoppers in cases where the chain is to be let go from the stopper, as it often is in surging, veering, etc.

CONTROLLERS are designed primarily to control the chain by catching it link by link as it comes in, so that if it slips on the capstan or if anything else goes wrong inside, no harm will be done. Each horizontal link, as it comes in, drops down abaft the lips of a heavy block, while the vertical link next forward of it drops into a slot in the top of the same block (Plate **70**).

A controller is sometimes used to hold the chain for surging, and even, in some ships, for riding. In such cases it should not be trusted alone, but should always be backed up with a stopper. It is not advisable to ride in this way with the ordinary controller.

In the merchant service, the controller is called a *compressor*.

Certain types of controllers are fitted with heavy coiled springs designed to take up the jerks on the chain that come in riding at anchor in a seaway. Such a controller, supposing it to be strong enough for its work, should be an excellent thing to ride by. Merchant steamers frequently tow by their controllers (compressors).

BITTS (Plate **70**), are heavy cylindrical iron castings firmly secured to the deck. The chain is taken around these with one or two turns, for letting go and for riding.

TO BITT A CABLE.—Enough slack chain is roused up from below to admit of throwing a turn over the top of the bitt, and the compressor is hauled to, to prevent this slack from running back. The bight is lifted and dropped into place by a light tackle hooked to a beam overhead. As bitted, the part leading forward is underneath and outboard, the upper (and after) part being held up clear by a lip on the outside of the bitt (Plate **70**).

TO UNBITT, the chain must be well secured forward by stoppers. Enough chain is then roused up to give slack for lifting off the bight by a tackle from overhead as in bitting.

TO BRING THE CHAIN TO THE CAPSTAN, it is unbitted, and the slack chain (with as much more as is needed) is hauled around the capstan abaft, the links engaging the sprockets of the capstan through about one-half the circumference. The rollers (which have been previously unshipped) are now shipped, inside the bight of the chain, holding it on the capstan and giving it a lead back to the chain pipe.

In heaving in, the slack chain is hauled around the rollers by men working with chain-hooks, and either paid below or ranged on deck. At the proper point, indicated by marks on the chain, the compressor is hauled to, and the remainder of the chain, giving slack enough for bitting and surging, is ranged on deck.

In ranging chain, care must be taken that the part leading to the hawse (which will be the part to run out first) is on the outside. If the outside fake were left to run out last, there would be a violent inward sweep of the bight as the chain tautened out from the chain-pipe to the hawse.

When the anchor is up, a good stopper is passed forward of the bitt, and the capstan "walked back" until the stopper has the weight. The chain is then taken off the capstan and bitted, a little slack being left forward of the bitt to insure that the anchor shall not hang in surging. If, now, there is not enough slack chain on deck for surging, more is roused up, and the compressor again hauled to. In the meantime, as soon as the chain is secured by the stopper, the cat is hooked and hauled taut. At the order "Surge," the stopper is slipped, the anchor swings to the cat and is run up to the bow. When it is secured, any slack that may be left is paid below. The compressor is left hove back, clear for letting go the anchor when it is wanted.

WINDLASSES.

There is a great variety in the windlasses used for handling anchors and cables in modern steamers, almost every firm of shipbuilders having a type of its own. Certain general features, however, are common to them all. A steam-engine turns a shaft, either horizontal or vertical, on which is mounted a "wildcat" or "chain-grab," over which the chain passes and by which its links are engaged. The wildcat turns loosely on the shaft, but may be rigidly secured to it by some form of connection, and much of the individuality of different types of windlasses lies in the nature of this connection. The wildcat is secured to the shaft for heaving the chain in or out, but is disconnected in veering chain and in riding by the windlass; being controlled, when so disconnected, by a friction brake.

In most cases, a capstan (frequently on the deck above) is connected with the windlass in such a way that the two can be worked either together or separately.

A type of windlass well known in the United States, and used on many vessels of the United States Navy, is shown in Plate **71.**

This windlass is horizontal and mounted on heavy bitts firmly bolted to a bed-plate which furnishes also a foundation for the engine by which the windlass is operated. The connection between the windlass and the engines is a worm and worm-wheel gearing, the worm being placed beneath the worm-wheel and close to the bed plate;—an arrangement which admits of supporting it solidly and of running it in a bath of oil. The cogs of the worm-wheel are cast on a rim and bolted to a driving head which is rigidly keyed to the shaft. This arrangement admits of replacing the gearing if it becomes worn, without dismounting the windlass. The windlass shaft can be arranged to carry two, three or four wild-cats or chain grabs. These are mounted loosely on the shaft but can be locked to driving heads which lie alongside them and which are rigidly connected with the shaft. When so locked to driving-heads, the wild-cats turn with them and with the shaft, for heaving the chain in or out.

Figs. 3 and 4 show two plans for locking and unlocking the wild-cats. In both methods, the locking-pawls are actuated by a ring, loosely mounted upon the driving head. This ring can be turned either forward or backward by a lever shipping in holes provided for it at a number of points on the ring. As the ring turns, it throws out or draws in a series of pawls which are mounted on the driving-head and which, when thrown outward, engage projecting lugs on the wild-cat. In Fig. 3 the pawls are pivoted on the inner face of the driving-head, under the overlapping rim of the wild-cat. To move them in and out they are fitted with bolts which engage an eccentric groove in the locking ring. As the ring is moved in one direction, these grooves throw the pawls outward and cause them to engage the lugs on the inner periphery of the wild-cat, thus locking the latter to the driving-head. The reverse motion of the ring draws the pawls in and unlocks the wild-cat. The pawls and lugs in this device are concealed by the overlapping rim of the wild-cat.

In the device represented by Fig. 4, a solid block is moved in and out by a rib running eccentrically along the outer face of the locking ring. In this device (which is later than that of Fig. 3), the whole locking mechanism is in plain sight.

When the wild-cat is unlocked it revolves freely, allowing the chain to run out, except as it is controlled by the friction-band brake fitted to the outer rim of the wild-cat. This may be set down so hard as to hold the wild-cat absolutely, or it may be applied with just pressure enough to control the chain, allowing it to run out with any desired degree of speed. The delicacy of control thus afforded is one of the most valuable features of this type of windlass. It admits of snubbing the ship on her chain without shock even when she is going ahead with considerable speed.

Directions for Using the "Providence" Steam Windlasses on the U. S. Battleships "Kearsarge" and "Kentucky."

When coming to an anchorage see that everything is in order for letting go. Be sure that the chain-stopper pawl or block is up and the wild-cat is unlocked. Place a trusty man (with an assistant when the chains and anchors are large and heavy) at the hand wheel to work the friction band. When ready, let the anchor go and as it drops screw up the hand wheel slightly, so that slack chain will not run out and foul around the anchor stock.

In nipping the anchor do it gradually in all cases.

To lock the wild-cat, bear down on the locking lever; to unlock, lift up on the lever.

Plate No. 71.

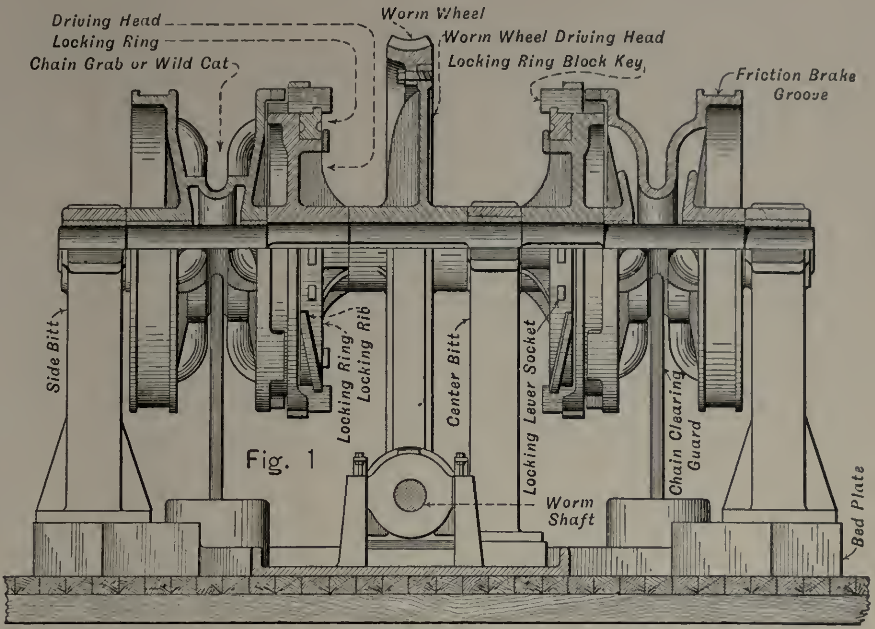


Fig. 1

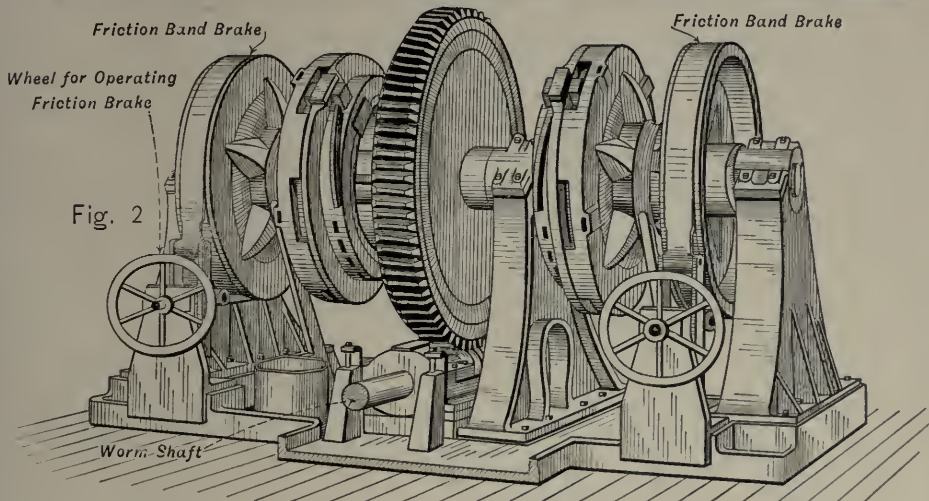


Fig. 2

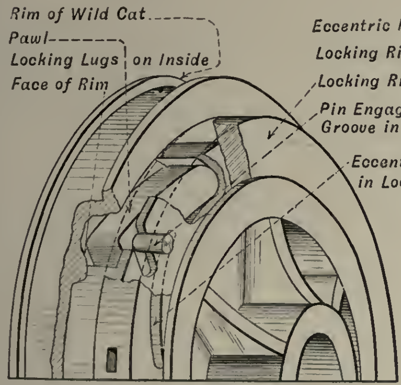

Rim of Wild Cat
Pawl
Locking Lugs on Inside
Face of Rim
Pin Engages Eccentric Groove in Locking Ring
Eccentric Groove in Locking Ring

Fig. 3 Locking Gear
Early Pattern

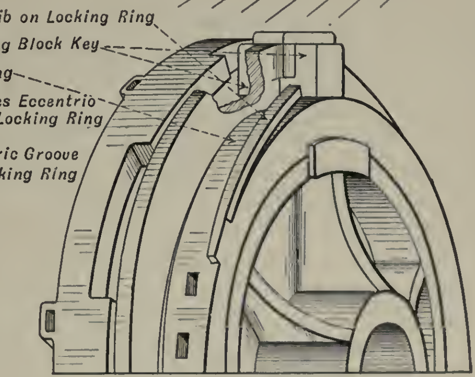


Fig. 4 Locking Gear
Later Pattern

ANCHOR WINDLASS.
U. S. S. BATTLESHIPS KEARSARGE AND KENTUCKY.

When desiring to heave up the anchor, lock the wild-cat to the windlass, see that the friction bands are slacked off, and that the chain stopper pawl or block is down.

When desiring to reverse the windlass for the purpose of overhauling the chain, it is only necessary to reverse the engines. With this type of engine, no pawls are used.

Directions for Keeping the Windlass in Order.

Keep all the bearings well oiled. Oil holes and automatic lubricators are provided for all the bearings. They should be kept free from dirt and regularly inspected. Use none but the best sperm oil for bearings. A mixture of equal parts of black lead and tallow makes the best preparation for the worm-wheel and worm to prevent cutting and wear.

The windlass should never be run without the gear teeth and worm being well slushed with black lead and tallow, a can of which is sent with every machine, and which should be replaced with more of the same material.

When the windlass is not in use, the cylinders and steam-chest drips should be left open, so as to drain all the condensed steam from the engines.

When starting a windlass for the first time it should be handled carefully and under the direction of an experienced person. Run it at first without any load till the bearings and worm and worm gear teeth are perfectly lubricated.

In some windlasses, the friction brake takes the shape of a disc or a set of discs keyed on the shaft but movable along the line of its axis by a screw or a lever, by means of which they can be jammed up more or less tightly against the face of the wildcat.

In Baxter's windlass, which is widely used in the English Navy, an arrangement of this kind acts both as a brake for governing the wildcat as the chain runs out, and as a connector for securing the wildcat (or chain-holder) to the shaft of the windlass for heaving in. The degree of pressure on the friction discs may be made just sufficient to control the wildcat, or may jam it tightly enough to admit of heaving in. The windlass has a vertical shaft, and the friction plates lie above the wildcat, upon which they put considerable friction, by their weight, at all times.

If the windlass has no wildcat for the sheet cables, the ship should be fitted with bitts for working these.

LETTING GO.

If the anchor is an old-fashioned one and secured for sea, the lashings must be come up and the inner fluke lifted to the top of the bill-board and eased out by the stock and bill tackles until it hangs by the shank painter, on the outer, sloping, face of the bill-board. It is then let go "stock and fluke" by means of a trigger which releases both ends at the same time.[1] The chain is bitted before letting go.

In some ships, the practice is to cock-bill the anchor for letting go, easing the crown down by the fish-tackle until the anchor hangs vertically from the cat-head. This insures its falling crown first.

Merchant steamers often go still further, hooking the cat to the ring and lowering it away while heaving in the slack of the chain, until the anchor hangs at the hawse-pipe by the chain alone, ready for letting go from the windlass.

Anchors stowed as in Plate **81**, are usually let go "stock and fluke," like the old-fashioned ones described above, by pulling a trigger which releases both ends and allows them to slip from the bill-board.

The precautions to be observed in letting go from the hawse-pipe by releasing the windlass brake have been described in connection with windlasses.

Modern ships are not usually fitted with riding-bitts, but when they are, it is well to bitt the chain if the anchor is to be let go from the bow. This saves the wildcat from the sudden shock due to the tautening of the chain as the anchor drops, and assists the friction brake in snubbing;—the operation which puts the ground tackle to the severest test that it is ever called upon to stand. Old-fashioned ships were brought-to by nipping the chain with the compressor; and as there was here no "give," the shock of bringing the vessel up was sometimes very severe upon both the compressor and the cable. It is one of the most important advantages of modern windlasses that they provide a means of bringing-to gradually and easily.

Where the anchor is to be let go from the hawse-pipe, or where for any other reason it is desirable that the chain should run out very freely, it should not be bitted. The brake gives a far better control in such cases than the old-fashioned compressor ever gave.

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[1] In passing the stoppers of the anchor, care should be taken that the end which is to unreeve in letting go is brought in *over* the anchor, so that in letting go this end will be thrown out and down. If passed underneath, it will be thrown up and in as the anchor drops and may swing in with dangerous violence.

The ship should always be moving slowly when the anchor is let go, and preferably astern. This prevents paying slack chain down on top of the anchor and fouling it. The tauter the chain can be laid out, the better, provided no chance is taken of starting the anchor.

With a stockless anchor, there is not the same danger of fouling and some officers claim that with this anchor there is an advantage in paying chain down on top, in that the added weight may make the anchor bite when otherwise it would not do so. This is contrary to the generally received opinion.

§ IV. RIDING AT SINGLE ANCHOR.

Vessels having windlasses of the type that has been described are not usually fitted with riding-bitts, the wildcat taking the place of these, and the chain being further secured for riding, by stoppers. The wildcat is unlocked from its driving head and held only by the brake, which should be lashed down. It is a common practice and a good one to leave the block of the controller down, with a link of the chain lying on it but clear of the shoulder by some three or four inches. So long as the brake and the stoppers hold, there is no weight on the controller; but if anything slips, the link brings up on the shoulder and is securely held. If it becomes necessary to veer, the stoppers are cast off, the block of the controller lifted, and the chain veered and controlled by the brake. If the wildcat were locked and the windlass held by the main pawls, it would be necessary to heave back, before veering, in order to release the pawls. In this way, moreover, the chain would be held rigidly upon the windlass, and the relief which might be given by the yielding of the friction brake under an excessive stress, would be sacrificed. In cases where such excessive stresses are to be anticipated, as for example when a vessel is *compelled* to ride to a short scope of cable in a seaway, it is a good plan to dispense with stoppers and to ride by the wildcat alone, with the brake set up fairly taut. The violent jerks upon the chain will cause the brake to *give* from time to time, and a little chain will be paid out, relieving the strain, and preventing the ship, it may be, from starting her anchor or parting her cable. *The brake, although lashed, must be attended by a careful man, and jammed down harder the instant the chain starts* *running out.*[1] Steam should be kept on the windlass, and when as much chain has been allowed to run out as it is thought well to give her, the brake is jammed down hard, the wildcat locked and the cable shortened in, after which the wildcat is again unlocked and the ship left riding as before. Except in such special situations as have been described above, it is better to take the initial tension of riding, by stoppers. Where a good scope of cable can be used, the necessary "give" will be found in the elasticity of the sagging bight.

The advantages of a long scope of chain are universally recognized, but probably few seamen realize in just what ways such a scope contributes to the safety of the ship and the ease with which she rides.

Perhaps the most obvious gain is in the angle at which the pull of the cable comes upon the anchor. The longer the scope, the more nearly parallel to the bottom this pull will be; and the smaller, therefore, will be the tendency to break the anchor out. If the length and weight of the chain are such that any part of it rests upon the bottom, then the weight of that part is added to the weight of the anchor, and helps in this way to hold the ship. It has been found, however, that in the case of a ship riding to a moderate gale in ten fathoms of water and with 100 fathoms of chain, not a single link of the chain rests undisturbed upon the bottom. It is therefore clear that this point is not of as great importance as is commonly supposed. It is only in the two ways above described that a long scope is of value to a ship *which is pulling steadily at her cable;* but the moment she begins to sheer about, or to rise and fall in a seaway—alternately ranging up toward her anchor, then driving heavily back upon her cable—the value of a long scope makes itself felt in the elasticity of the bight, which prevents the rapidly varying tensions from being thrown upon the cable and the anchor in a succession of violent shocks. The cable never leads in a straight line from the hawse-pipe to the anchor, but dips downward in a curve, the degree of curvature depending upon the depth of water, the length and weight of the cable, and the tension to which it is subjected. With a long scope of chain, under a moderate tension, the curvature is very marked. If, now, a ship riding in this way begins to drive astern before a heavy squall, she must lift the bight of her cable as she moves; and the longer and heavier the bight, the more work will be involved in lifting it, the more slowly the ship will move astern, and the more gradually the tension on the anchor and the chain will reach its maximum. It is one of the commonplaces of mechanics that a force has far less destructive effect when exerted gradually, than when exerted suddenly; and all experience confirms this principle in its application to a vessel riding at anchor as above described.

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[1] The pressure which would give sufficient friction to hold the wildcat from starting would not suffice to keep it under control after it had once begun to turn. This is the difference between statical and moving friction.

It is a common rule to give, under ordinary circumstances, a length of cable equal to five times the depth of the water. This is perhaps enough for a ship riding steadily and without any great tension on her cable, but it should be promptly increased if for any reason she begins to jump or to sheer about; *for it is always easier to prevent an anchor from dragging than to make it hold after it has once begun to drag.*

A vessel at single anchor in a strong tide-way is likely to sheer considerably, bringing the current first on one side and then on the other, and driving across the stream until brought up by her chain, often with a violent shock. This may be prevented in a great measure by holding her with a steady sheer—preferably away from her anchor—as in Fig. 6, Plate **72**. This is accomplished by putting the helm over as far as may be necessary, and keeping it there. The stern is driven over to one side and she is canted across the current and held there. She is thus in more " stable equilibrium " than when riding with the tide nearly or quite ahead; and while she puts a heavier tension on her cable, it is a *steady* tension, which, as already explained, is not a dangerous one.

A ship is never in greater danger of dragging her anchor or parting her cable than when driving down with a slack chain, broadside on, or partially so, to wind or tide. Such a situation may of necessity arise in anchoring, or may come about in sheering, as above described. It not infrequently happens in squally weather, where a ship swings in one direction during a lull, just in time to be caught by a strong squall on the beam and driven bodily off, to bring up, it may be, with the chain taut across the stem.[1]

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[1] A cable or a hawser is greatly weakened by a bend or " nip," such as will exist at the hawse-pipe if the cable leads off at a sharp angle from the pipe.

In lying at an anchorage where such situations may arise, the greatest watchfulness should be exercised, steam being kept on the steering engine, and a man at the wheel,[1] an ample scope of chain veered, and a second anchor ready for letting go at a moment's notice. The last-named precaution should in fact be always taken; that is to say, a second anchor should always be ready, even though there seems no chance of its being needed.

Evidently, the danger of dragging is greatly increased if the anchor is foul. It seems to be generally considered that when riding at single anchor, the question whether an anchor is clear or foul is altogether a matter of chance, with which nobody on board the ship has anything to do. This was not so in the old days of seamanship, when the art of "tending ship" was an important part of the seaman's profession. The change is probably due in a large measure to the fact that anchors are now rarely *buoyed*, because of the danger that the buoy-rope would foul the propeller. It is no doubt difficult to keep a ship clear of her anchor with no means of telling where the anchor lies; but something can be done by watchfulness and care, if only to coax the ship by helm and spanker to swing always to that side of her anchor which will kept the chain from taking a turn around the stock; that is to say, if she has swung once to the eastward of her anchor, she should, if possible, be made to swing back on the same side.[2] If she swings to the westward, and if the anchor fails to turn in the ground, the chain takes half a turn around the stock.

Whether or not the anchor turns with the ship will depend upon the tension of the chain. If a fair tension is kept up while the ship is swinging—that is to say, if for any reason she swings in a circle of which her more or less taut cable is the radius—the anchor will turn slowly and keep its hold steadily, in addition to keeping itself clear. If, as more often happens, the ship swings with her cable slack, riding, for the time being, to the bight of the cable rather than to the anchor, the anchor will not turn; and when the new tide makes and she finally tautens her chain, the crown will be pointed toward the ship, with the cable stretching from the ring along the shank. As, now, the cable pulls upon the ring, it may turn the fluke in the ground, or it may capsize the anchor and bury the other fluke; or, finally (if the tension is not great), the anchor may remain as it is; in which case the next swing of the ship will clear it or foul it, as already described.

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[1] If a ship parts her cable and starts unexpectedly on a cruise, she may be in a measure controlled by the helm if actually moving through the water, and so saved, perhaps, from going ashore or fouling other vessels, until she can be brought up by another anchor.

[2] The log should show the heading of the ship from hour to hour, in port as well as at sea, and a note should be made, each time she swings, of the direction in which her head changes.

Under conditions such that the anchor may be expected to foul, it is a good rule to "sight" it frequently; and indeed this is advisable under any conditions when a ship remains at single anchor for a long time. It is especially important if, after lying for some time under circumstances which make it probable that the anchor may be foul, bad weather is found to be approaching.

In many harbors, a swell sets in on the beam of vessels riding to the wind, causing them to roll incessantly. In such cases, a stream anchor planted off the bow, with a line from the quarter, admits of springing around, head to the swell. In the tropics, a similar plan adds much to the coolness of the ship by bringing the wind abeam.

When anchoring in a narrow river or harbor where there is little room for turning and where occasion may arise for leaving hurriedly, it is well to keep a hawser triced up along the outside from the warping chock on the quarter to the hawse, ready for clapping on the chain. If an emergency arises while the ship is heading in, the spring is bent to the cable, and the cable unshackled. The ship then swings, the line is buoyed and cast off, and the ship stands out.

A man-of-war anticipating an engagement at anchor—a situation not often to be expected in modern warfare—would always have springs in readiness, leading from each quarter to the anchor, or, better, to kedges planted off the bow. The familiar story of the Saratoga at the battle of Lake Champlain illustrates this point impressively as a matter of both seamanship and warfare.

In preparing for action, she planted a kedge off each bow, with a line leading to the quarter, and hung a stream anchor over the stern. At a critical period of the engagement, all the guns of her engaged broadside having been disabled, the stream anchor was let go, with a line from its ring to the port bow, and the bower cable cut. The stern was hauled over to the kedge on the starboard hand, and the line from the other kedge dipped and brought in on the starboard quarter. (Figs. 1 and 2, Plate 72.) With this line from the starboard quarter and the line from the port bow to the stream anchor, she was sprung entirely around, bringing the new broadside to bear. This manoeuvre decided the engagement.

It is always advisable to keep a shackle where it can be gotten at conveniently for slipping suddenly if an emergency arises, and to be sure that the pins can be driven out without difficulty. Tools for unshackling should be kept in a convenient place and never removed. A buoy and buoy-rope at hand complete the preparations for slipping at short notice. In an exposed anchorage, subject to sudden gales, these precautions are of course especially important.

If, when lying at anchor in a tide-way, a vessel or other danger is seen drifting down upon you, you may, by giving the ship a cant with the helm, bringing the current on the bow, and veering away roundly, sheer well over across the tide and probably clear of danger.

If an anchor is known to have dragged, in a clayey bottom, it should be picked up as quickly as possible; for it is certain to be "shod," and to have lost much of its proper holding power. In letting go where the bottom is of this kind, it is important to give a good scope in the very beginning, to prevent even the little dragging that is commonly to be expected as the anchor digs down to get its hold.

In riding out a gale, it may often be necessary to let go a second anchor, but there can be no question that where unlimited space is available, a ship is safer and easier with a single anchor and a long scope of chain; and by a "long scope" is not meant 45 or 60 fathoms, but twice that length, or even more. Two cables will hold a ship longer if bent together and veered out to the double length on a single anchor, than if used separately, each with its own anchor down. It must not be overlooked, however, that a defective link or shackle may result in disaster where a single cable is in use; and this may make it wise, apart from other considerations, to let go a second anchor in cases where no chances can be taken.

When the conditions are such that there is a possibility of starting the anchor, a lookout should be kept which will insure instant notice if she begins to drag. The *drift lead* is useful,

Plate No. 72.

The Saratoga at the Battle of Lake Champlain

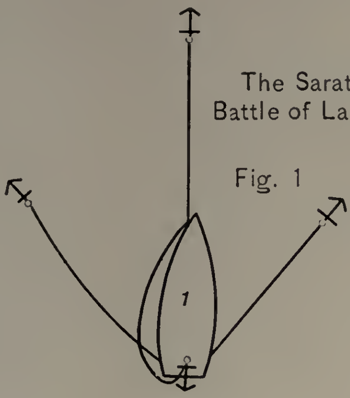


Fig. 1

The Saratoga at the Battle of Lake Champlain

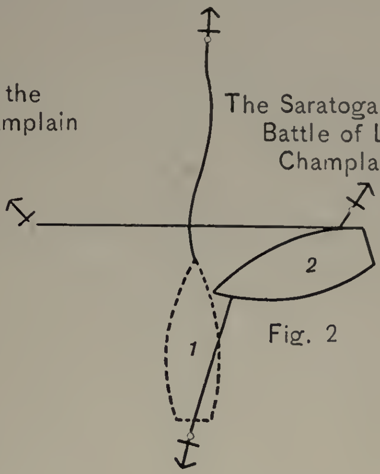


Fig. 2

Riding to an Open Hawse

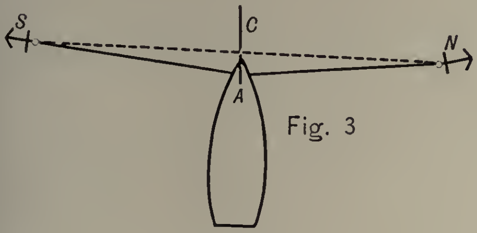


Fig. 3

Riding to an Open Hawse

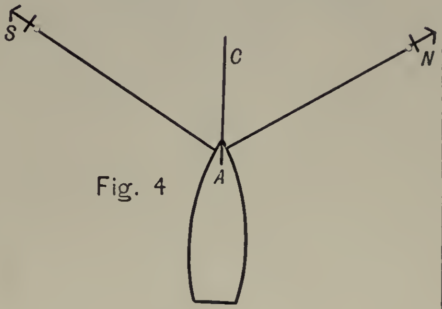


Fig. 4

An elbow in the Hawse

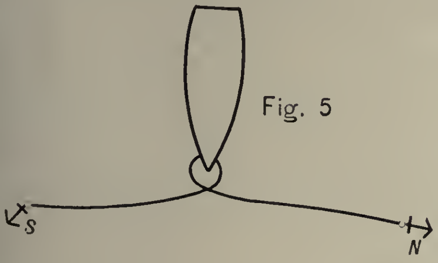
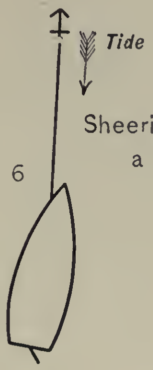


Fig. 5



Sheering a Ship in a Tide-Way

Fig. 6

ANCHORING WITH A SPRING, MOORING, ETC

though not always to be trusted. This is a heavy lead, kept on the bottom, with its line made fast to some place convenient for observation and left hanging with considerable slack. If the ship drags, the line tautens and tends ahead.

So long as a ship is fairly steady, a drift lead will usually give notice in case of dragging, but if she sheers about considerably, it cannot be relied upon. The farther forward it is used the better, as the bow moves much less than the stern in sheering.

Good *bearings* of objects on shore are more reliable than the drift lead, and a *range* is best of all; but these, also, are less trustworthy when the ship is sheering about than when she is steady; for a range will open out when the ship swings, and may seem to indicate that she is dragging. Its indications may be checked by watching the heading.

Where no range can be picked out on shore, two single marks *on opposite sides of the ship* answer well, if the observer takes his stand at some spot to which he can return from time to time, and notes a point on the ship itself in line with each of the points on shore.

Suppose, for example, that from a certain point on the bridge or deck, a shore mark to starboard is in range with a swifter of the rigging, an awning stanchion, or some other conspicuous point of the ship; while another object to port is similarly in line with something on the ship along the port side. As the ship swings, one object will draw ahead and the other will draw aft. If she drags, both will draw ahead.

If the compass is conveniently placed for observation, a single bearing upon an object near the beam and at a reasonable distance, will give all that is needed, although here, also, allowance must be made for swinging.

It sometimes happens that the ship can be felt to start, by a slight jar due to the sudden slacking of the chain as the anchor lets go its hold; and if she drags for any distance, there will almost always be a tremor in the chain, perfectly perceptible to the hand, due to the variation in resistance which the anchor meets as it moves along the bottom. This is a good thing to know in cases where no other indications are available.

§ V. MOORING.

A vessel is moored when she has two anchors down at a considerable distance apart and with such a scope of chain on each that she is held with her bow approximately stationary on the line between them.

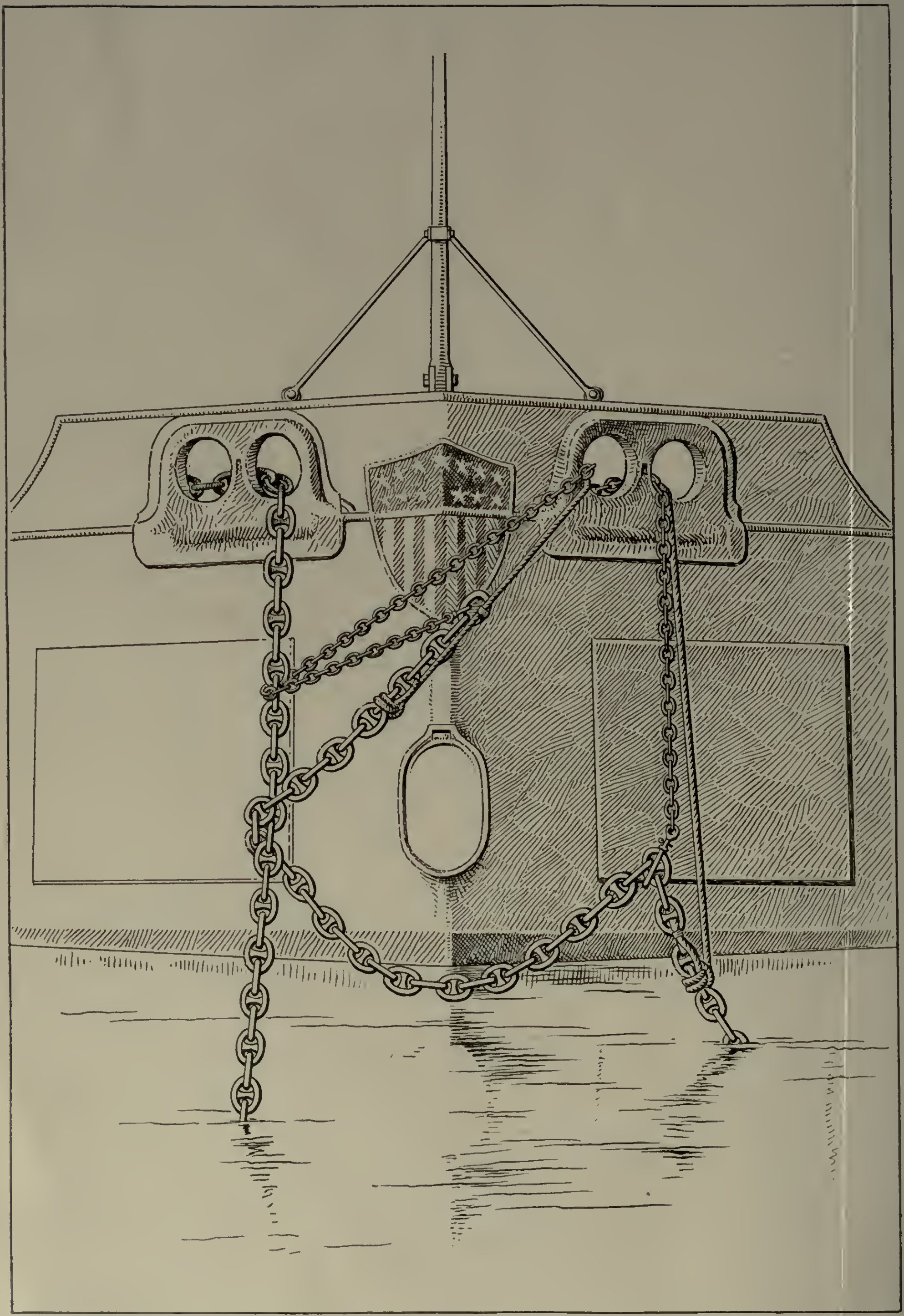
A vessel so placed may head in any direction, but will swing, roughly speaking, about her own stem as a pivot; the amount by which she deviates from this depending upon the tautness with which she is moored.

The advantages of mooring are that a vessel takes up comparatively little space in swinging and that she cannot foul her anchors by dragging the bight of the chain over them. The disadvantages are that she must often ride to a span, and must either be hampered by a mooring swivel or have constant difficulty and annoyance from a foul hawse. So long as she rides to a wind or current setting along the line on which her anchors are laid out, she is practically at single anchor, though she may of course drop down beyond the leeward anchor and hold on with both cables taut ahead. But if a gale comes up from any direction athwart the line between her anchors, she rides to a span, and the tension on the cables will be altogether out of proportion to that utilized in holding the ship. In Fig. 3, Plate **72**, suppose A riding to a gale from the east, her anchors being laid out on a north and south line and the cables making an angle of 10° with this line. If the force acting on the ship along A C is 20 tons, the tension on each cable will be 57½ tons.

Thus, under conditions such that a single anchor and cable ahead would have to bear a tension of only 20 tons, two cables in a span are subject to a total tension of 115 tons. If the angle N A S is more obtuse, the tension is increased. If the ship veers and drops to leeward, bringing the cables more nearly ahead, the demand upon them becomes less; and when the angle N S A is 30°, the two cables together have exactly the holding power that one would have if laid out singly ahead (Fig. 4, Plate **72**). As the ship continues to drop down, the cables act more and more efficiently, and if a long enough scope is given, their holding power becomes nearly double that of either one alone.

It will be clear from this, that in riding out a gale with open hawse it is even more important than with a single anchor, to veer as long a scope as may be possible. If such a situation is anticipated at the time of mooring, the anchors should be laid out closer together than they otherwise would be; indeed, there is always an advantage in mooring with rather a short scope on each

Plate No. 73.



Clearing Hawse.

chain (provided such a length is used that she cannot swing over her anchors); for if a gale comes up along the line of the anchors it is easy to veer the riding cable and drop down to leeward, bringing both anchors ahead, where they will act better the closer they are together; and in riding with open hawse, the same point gives the advantage which has been illustrated above.

CLEAR AND FOUL HAWSE.

A vessel moored has a "clear hawse" when her cables lead off on their respective sides, clear of each other. She has a "foul hawse" when they are crossed or otherwise foul of each other.

In Fig. 3, Plate **72**, A rides with an "open hawse," heading west, her starboard anchor being to the north and port anchor to the south. She may swing through eight points to either side without crossing her cables; and so long as she swings backward and forward, *her stern going each time to the eastward*, the hawse will remain clear. The moment her stern swings to the westward of the north and south line, however, the chains begin to cross. In Fig. 5, she has swung through half a circle from an open hawse, and has now a "cross" in the hawse. If before swinging to the westward she was riding to the starboard anchor, the starboard chain will now be on top; and to swing clear, her stern should go back to starboard. It is a rule easily remembered, that to clear the hawse by swinging, the stern must always go toward the side of the cable that is on top.

If, having swung in such a way as to put a cross in the hawse, she continues swinging in the same direction, she puts in, successively, an "elbow," a "round turn," a "round turn and an elbow," and so on.

It is evident that a foul hawse will be cleared if the ship can be made to swing back in the direction opposite to that in which she has swung in fouling; and with a little watchfulness this may often be done, by giving her a cant with a helm on the last of a tide, or by taking advantage of a breeze to cant her with a jib or spanker. The hawse may often be kept clear in this way when it would otherwise foul; and the situations are frequent when a cross or an elbow can be swung out. In the case of anything more than this, it is better to proceed at once to "clear hawse," as follows:

TO CLEAR HAWSE (Plates **73** and **74**).

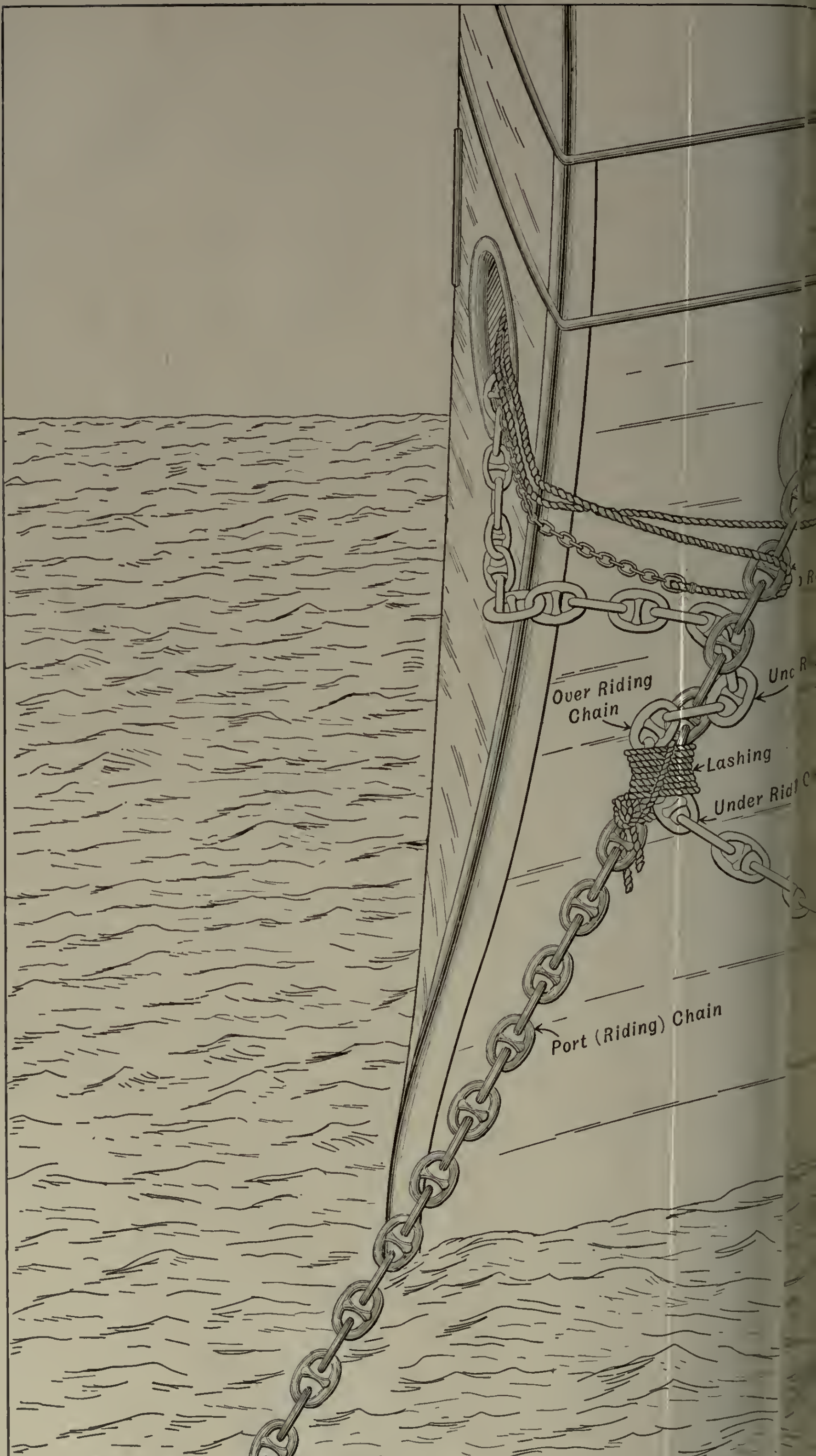
This should be done if possible at slack water, preferably just after the ship has finished swinging and before the new tide begins to run strongly. The lee chain is always the one to be unshackled, never the weather one. The clear-hawse gear consists of:

1. The clear-hawse pendant; usually a stout line of hemp or manila, tailed with chain, and fitted (at the end of the chain) with a slip-hook.
2. The dip-rope, a line of hemp or manila tailed with chain, the whole considerably lighter than the clear-hawse pendant, fitted with sister hooks at the end of the chain.
3. A hawser to be bent to the chain above or below the slip-hook of the clear-hawse pendant, as a preventer, in the event of parting the pendant.
4. A line on the chain from the inside, for easing out after unshackling. This is not always used, but is convenient and may be necessary with a heavy chain.
5. Deck tackles, hook-ropes, chain-hooks, straps, rope for lashing, tools for unshackling and shackling, etc.

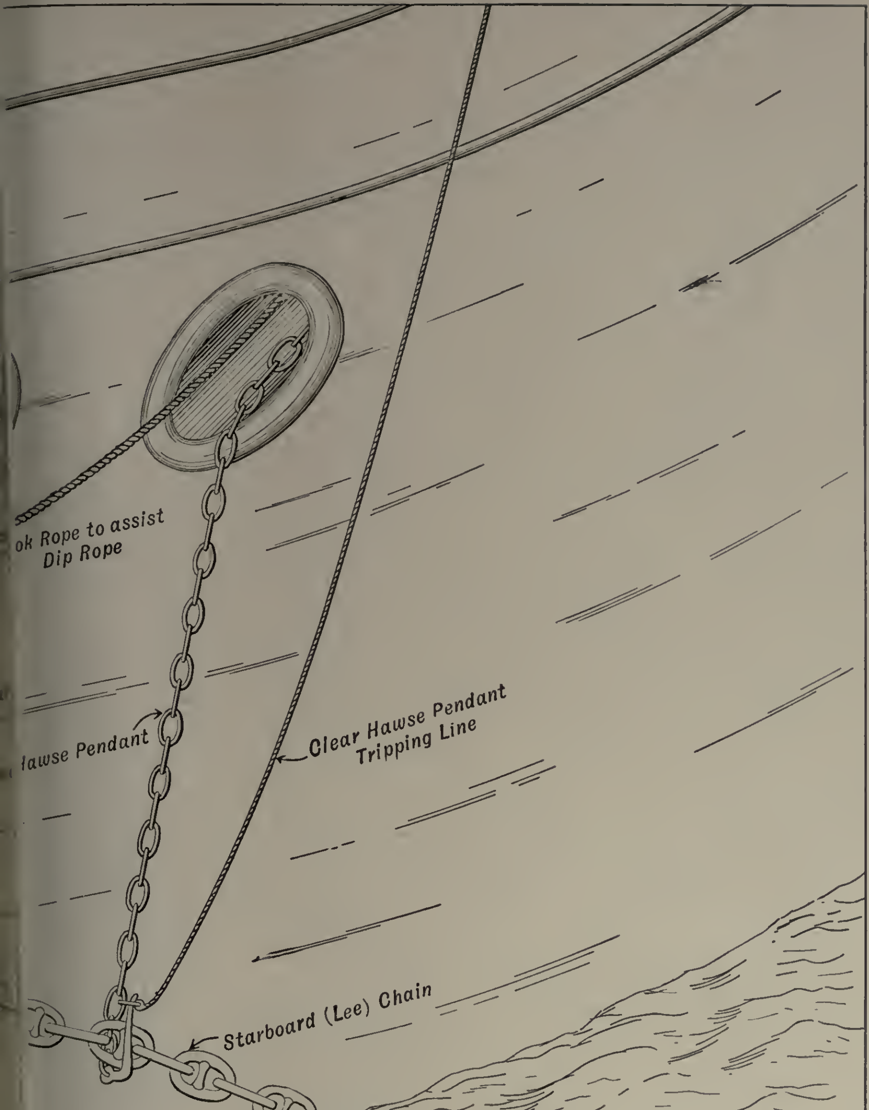
If the turns in the cables are below water, they must be brought above by heaving in the riding cable. If they are inclined to slip down—as may be the case if the chains are slack—they must be lashed; and many officers prefer to lash them in all cases. There is no question that this reduces the chance of accident, both to the cables, and, what is more important, to the men working them.

A ship with a ram-bow, having a foul hawse, will sometimes forge ahead, bringing the turns below the ram so that the cables lead up and down and seem to be clear. If proper entry has been made in the log of the swinging of the ship, this should not lead to misunderstanding, but it may cause considerable difficulty. If steam is available, a few turns of the screw astern will bring the turns up where they can be gotten at. In other cases, it will usually suffice to heave in on the riding cable and veer on the lee one. Much depends upon the shape of the ram and the position of the hawse-pipes, but there is always some way of handling the chains to meet this and other difficulties which arise in working ground-tackle.

The turns being above water, the clear-hawse pendant is passed



CLAR
BOTH CHAINS ON



SE.
SIDE OF RAM.

out the sheet hawse-pipe or through a warping chock, and secured to the lee cable below the turns, after which it is taken to the capstan or a winch, hove taut and secured.

In a ship with a ram-bow, the turns usually come up on one side of the ram;—the side of the riding cable (Plate **74**). In this case, the clear-hawse pendant, although still used on the lee cable, is passed out on the side of the *riding* cable.

The preventer hawser is also passed out, bent to the cable, hauled taut and secured.[1] If the turns are to be lashed, this is done now.

The dip-rope is passed out of the hawse-pipe alongside the lee cable, taken around the riding cable in a direction opposite that of the turns to be taken out, and brought back inside, where it is secured to the cable forward of the shackle; preferably to the end link.

The dip-rope is often made fast to the second or third link forward of the shackle, to leave slack on the end for convenience in shackling and unshackling; but this makes trouble when it comes to hauling the end in through the hawse-pipe; and the better way is to bend it to the end. Then, after the turns have been cleared and the end hauled in again ready for shackling, the chain is secured with a stopper, leaving plenty of slack end for working, and the dip-rope is cast off altogether.

The lee chain is engaged in the controller before unshackling, and may be further secured by a stopper if this is considered necessary. The end of the "easing out" rope is made fast a few links forward of the shackle and stopped to the end link. The cable is then slacked up and unshackled, the controller released, and the chain hauled out by the dip-rope, the end of which is taken to a winch.

The lead of the dip-rope is unfavorable for hauling out, and with a heavy chain it may be necessary to lead a line out on the side of the riding cable, and take it in through the lee hawse-pipe to assist in hauling out the end of the cable (Plate 74). Chain-hooks, hook-ropes, etc., are used inside for lighting the chain forward.

The dip-rope, assisted as before described if necessary, takes out the turns and brings the end inside the hawse-pipe, where it is secured by a stopper and shackled. The chain (lee) is then hove moderately taut, the controller released, the preventer hawser cast off, and the clear-hawse pendant tripped by means of the lanyard on the link.

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[1] This supposes that the preventer hawser is to *hold* the chain in case the pendant fails. If it is intended only for *weighing* the chain, it is left slack but the end is made fast.

In small ships the hawse is often cleared from a boat under the bow, the shackle being veered out into the boat and there unshackled, dipped, and shackled again. It is well in this case to lash the turns and to take the weight of the chain by slip-ropes from the bowsprit or forecastle.

Some ships have a light davit which can be stepped at the stem when needed for working chains. This is a great convenience and in many ships almost a necessity.

A *cross* in the hawse cannot be cleared, as the chains lead off on the wrong sides, the starboard anchor being on the port hand and the port anchor on the starboard hand. The chains may be unshackled and shifted, the former starboard chain becoming the port one and the port becoming the starboard, provided this does not interfere with stowing the anchors on their bill-boards.

If it becomes necessary to weigh when there is a cross, the anchor belonging to the cable *underneath* must be picked up first; as the upper one, if picked up, would foul the other chain.

It is clear from what has been said about the hawse, that it is not a matter of indifference in what way the anchors are laid out. In Fig. 3, Plate **72**, for example, they are properly placed provided the probability is that the wind, in the event of bad weather, will haul to the westward, thus keeping the hawse open. If the wind is more likely to haul the other way, the starboard anchor should be to the southward.

THE MOORING SWIVEL.

A vessel moored may avoid the necessity for clearing hawse by using a mooring swivel (Fig. 2, Plate **76**). This is much like an ordinary swivel, but larger and heavier and with two links and shackles attached to each of its parts. It is shackled upon the cables just forward of the stem in such a way that the parts of the cables leading from the hawse-pipes are connected to the inner shackles, and the parts leading off to the anchors, to the outer shackles. As the ship swings, the swivel turns and keeps the cable clear. It should be put on with the cup up.

There are some disadvantages connected with the use of the swivel. It is very inconvenient in veering, and still more so in

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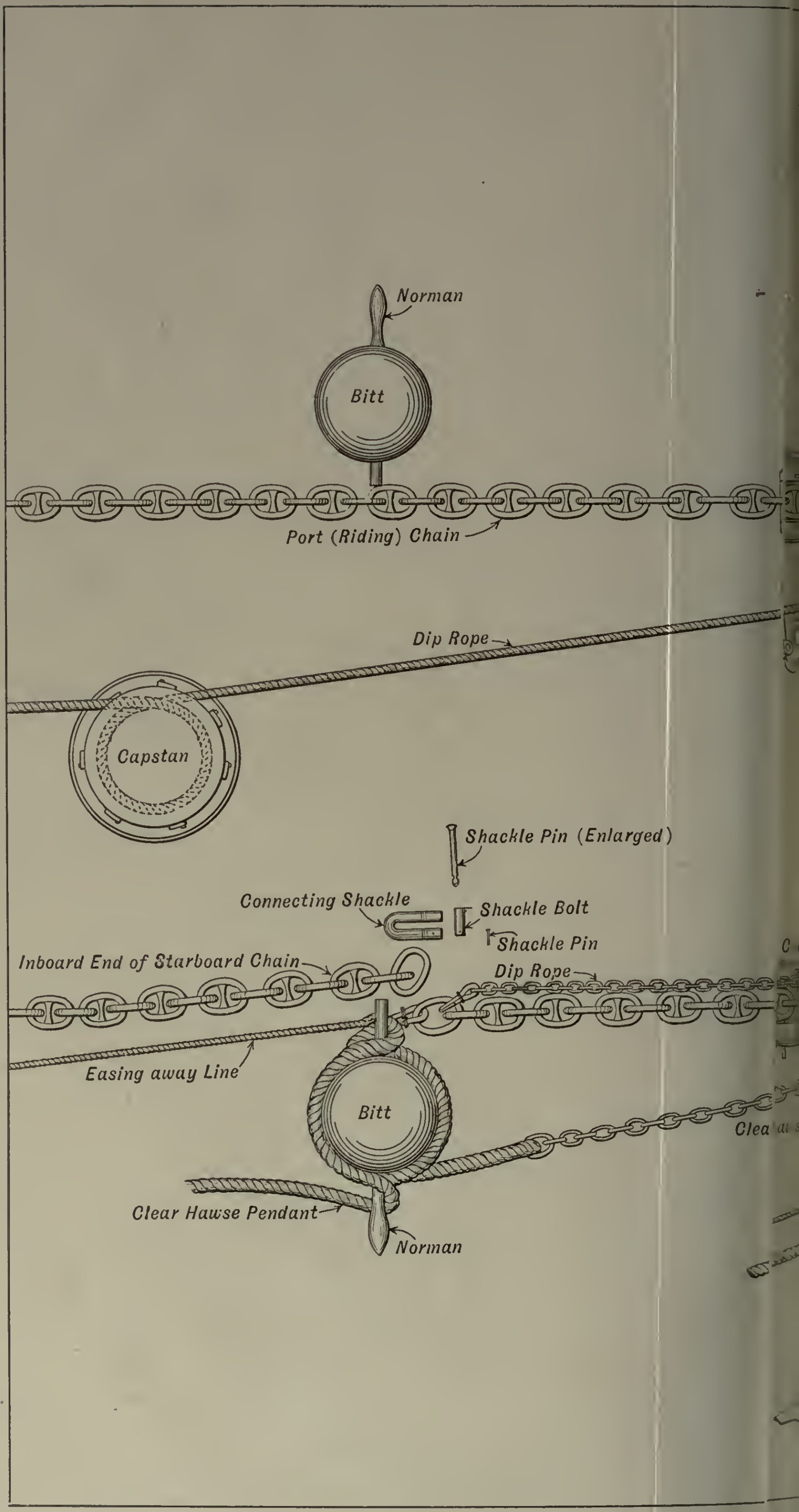
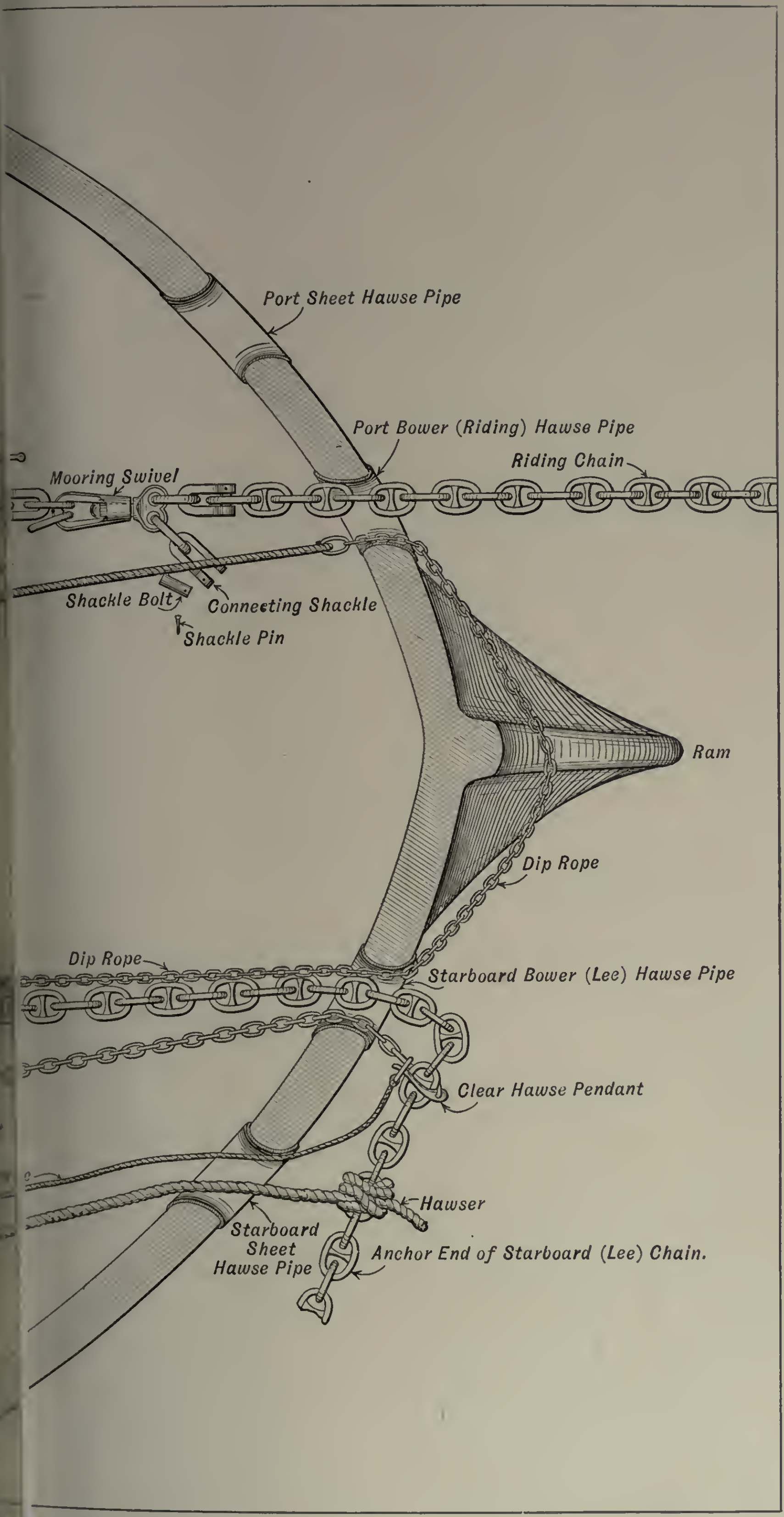


CONNECTING SWIV

5.



NSIDE HAWSE.

weighing, as it must be taken off before either anchor can be picked up. In spite of these disadvantages, it is almost invariably used by men-of-war.

In view of the difficulty in veering where the swivel is used, a vessel proposing to use it should moor with a good scope on each chain in the beginning. The conditions here are quite different from those where a ship is moored without a swivel and free to veer at any moment. Under the last-named conditions, as has been explained, there is a certain advantage in having the anchors not too far apart, but this reasoning does not apply if the swivel is to be used.

As both clearing hawse and putting on the mooring swivel involve unshackling, the scope on each cable in mooring must be made such as will bring a shackle near the hawse. Where the cables are made up of 15 fathom shots, we may use 30, 45, 60 or 75 fathoms on each. In the United States Navy, the latest cables issued to ships have no shackle between five fathoms and forty-five, so that nothing less than forty-five fathoms can be used on either cable (in mooring).

It is usual in laying out the cables to bring the shackles a little inside, but not so far as in cases where the swivel is not to be used. This is because the insertion of the swivel slacks the cables considerably, and with a slack moor there is danger that the swivel will not turn. The exact position for the shackles will depend upon the depth of water and the construction of the ship.

It is a common and convenient practice in using the swivel to connect only one cable from the hawse, the end of the other being kept inboard. This does not involve any loss of holding power, for the reason that, so long as the ship rides to one cable only, the single part leading inboard is as strong as that from the anchor; and when she rides with an open hawse, the parts beyond the swivel form a span, which, as has been shown, has actually less holding power than a single part acting along the line on which the ship is pulling.

Some ships shackle both chains from inboard to the swivel, and to prevent them from sawing across the stem leave one of them slack and dip the bight of it down under the fore-foot. They thus ride to a single part, but have the other to rely upon in case of accident and can heave the swivel up to either hawse-pipe for taking it off.

PUTTING THE SWIVEL ON.

It was formerly the rule to put the swivel on the lee chain first, then to wait for the ship to swing before putting it on the other one. This is still the rule in cases where the swivel is put on *outside the hawse.* But many modern ships have hawse-pipes large enough to let the swivel and several parts of chain pass freely; and in such ships it is put on inside, *and on the riding cable first,* the lee cable being afterward secured by the clear-hawse pendant as in clearing hawse, unshackled, and the end coming from the anchor hauled around the stem and inside the riding hawse-pipe, where it is shackled in its place on the swivel.

The details of this method are shown in Plate **75**.

The first thing to be done is to heave in on the *riding cable* until the shackle is at a convenient point for working, when the chain is secured by the controller and one or more stoppers, all of course forward of the shackle. The riding cable is then slacked and unshackled, and the swivel shackled in place. In the meantime, the clear-hawse pendant has been put on the lee cable and hove taut, and a preventer hawser made fast, as in clearing hawse. The dip-rope is passed out through the riding hawse-pipe, brought in the lee hawse-pipe, and made fast to the lee cable just forward of the shackle.

The lee chain is next unshackled inside, and the end of it leading from the anchor is hauled out by the dip-rope across the stem and in through the riding hawse-pipe, where it is shackled to the *forward* end of the mooring swivel. The riding chain is then veered away until the swivel is outside.

If, now, it is proposed to connect the other part of the lee cable (from inboard), this part is hauled out by the dip-rope and shackled in its proper place on the swivel.

If the hawse-pipe is large enough to take the swivel, but not large enough to take the two cables alongside each other, the swivel is put on the riding cable as just described and then veered outside, before connecting up the anchor end of the lee cable; the clear-hawse pendant, dip-rope, etc., being used as before, except that the dip-rope in this case would be rove a little differently; perhaps through a link of the riding cable just below the swivel, or even through the swivel itself; the idea being to get the end of the chain to the point where it is wanted, by whatever means is most convenient (Plate **76**). In this case also it is necessary to bend the dip-rope to the cable several links forward of the

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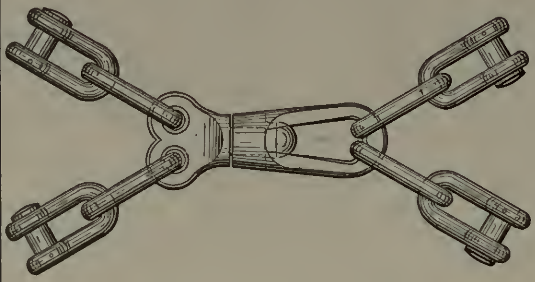
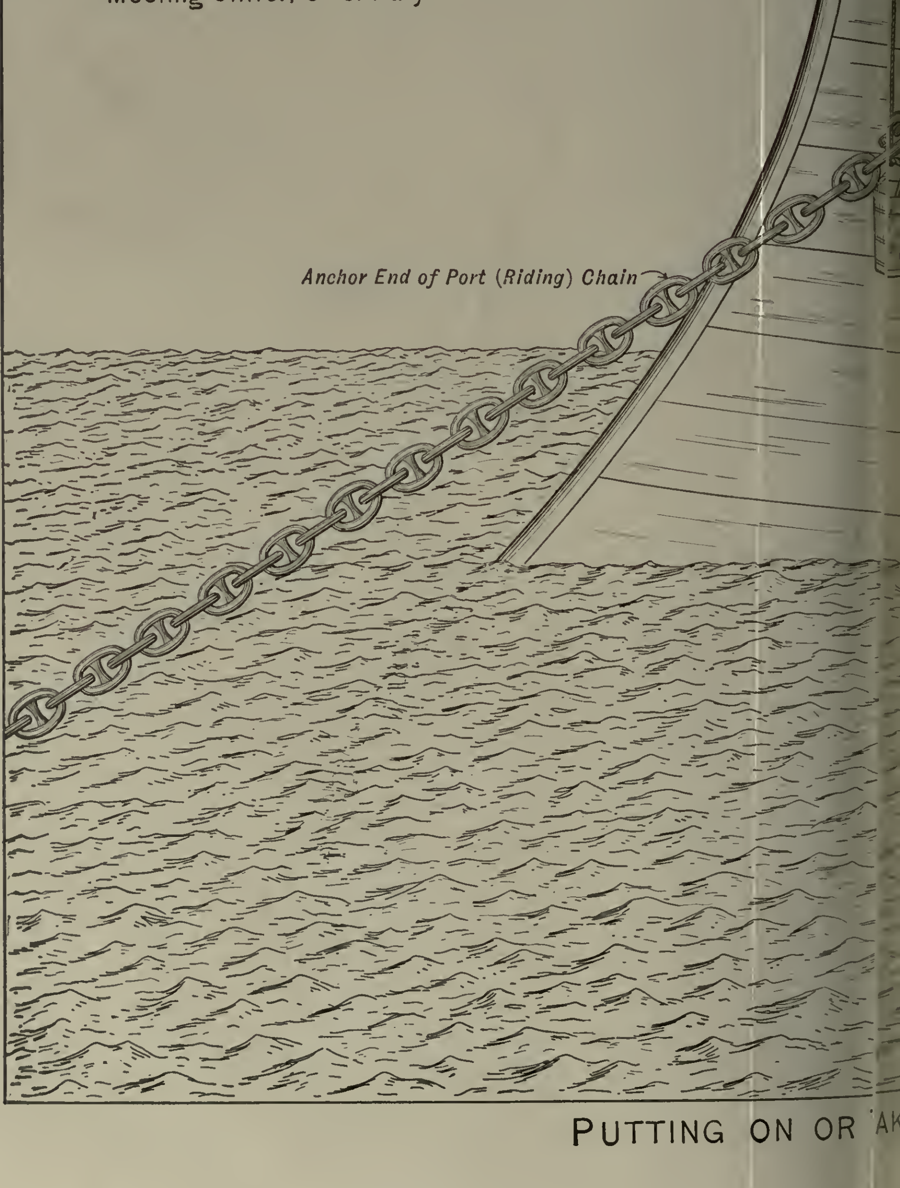
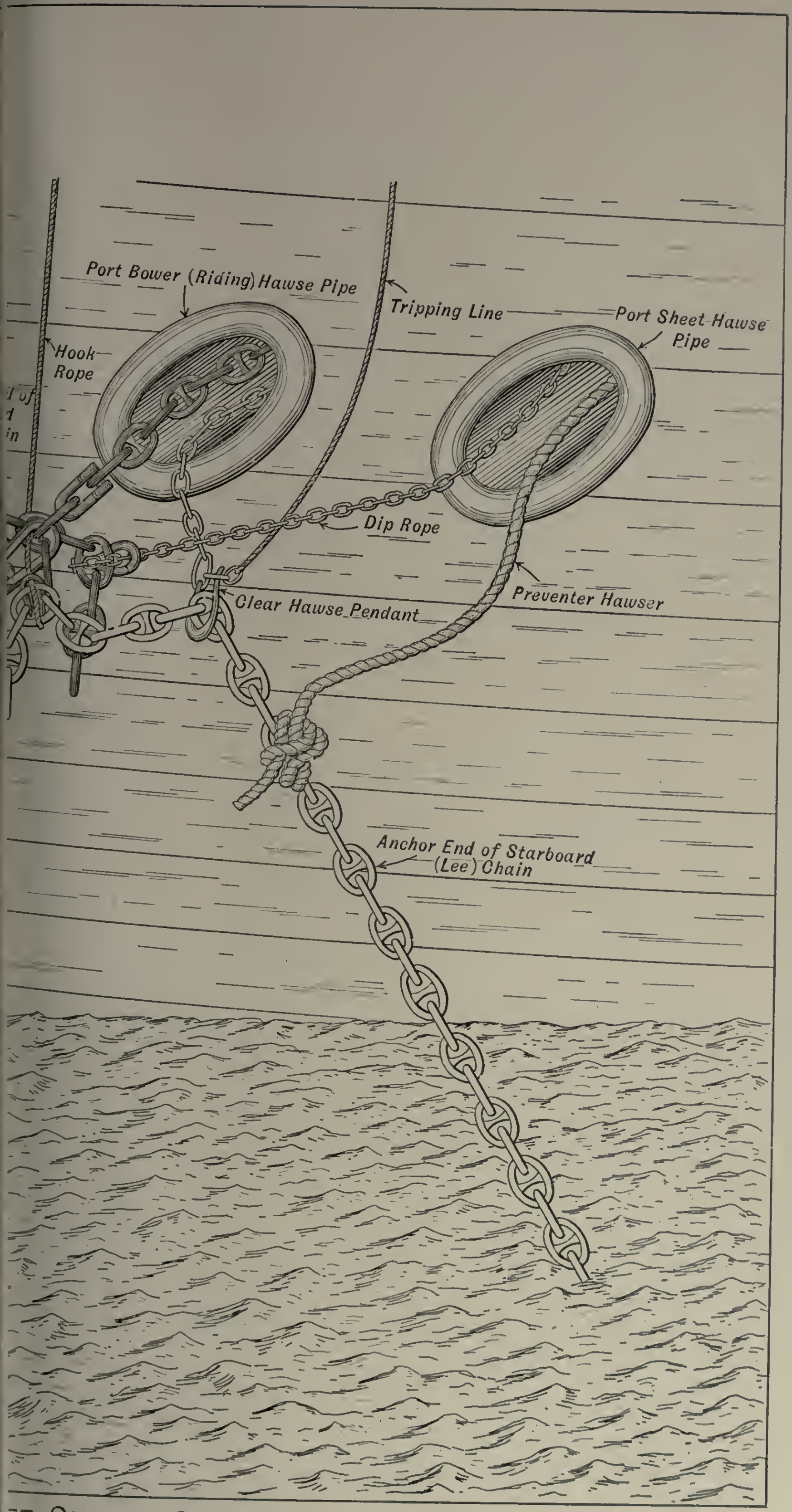


Mooring Swivel, U S. Navy.


Anchor End of Port (Riding) Chain

PUTTING ON OR AK

76.



F SWIVEL OUTSIDE

end, to give the slack required for shackling. The men handling the chain work either in a boat under the bow or on a stage slung over from the forecastle, such lifting as is required being done by slip-ropes, and all shackles, mauls, etc., being slung by lines to avoid danger of their being lost.

Different ships will call for different ways, and methods best suited to each individual case must be worked out by practical experience.

If the swivel cannot be put on either cable inside, it must be put on the lee cable first, the shackle being veered outside, the cable secured by the clear hawse-pendant and a hawser, and the swivel lowered over the bow and put on by men working in a boat or on a stage. When the ship has swung, bringing the other cable to leeward, this is handled exactly as has been described for connecting the lee cable in the case where the swivel was put on the riding cable inside and veered outside.

TAKING OFF THE SWIVEL (Plate **76**).—Secure the lee chain as for clearing hawse; that is to say, put the clear-hawse pendant and preventer hawser on that part of the lee chain leading from the anchor and heave in on the clear-hawse pendant until there is slack enough between it and the swivel for unshackling. If the inboard end of the lee chain is shackled to the swivel, stick out slack enough for unshackling it also. If this end is not attached to the swivel, haul it out by the dip-rope leading from the weather sheet pipe. Hang both parts of the lee chain by good lines from the forecastle. Unshackle both ends from the swivel and shackle them together. Heave the lee chain taut, take off the hawser and slip the clear-hawse pendant. Heave in on the riding chain until the swivel is abaft the controller. Secure the chain by the controller and stoppers, unshackle the ends from the swivel and shackle them together.

If the swivel will not go through the hawse, it is desirable to wait for the ship to swing before taking it off the second chain. Thus each chain is a lee chain when it is disconnected.

If it is impracticable to wait for this, handle the riding cable as already described for the lee one, but with extra precautions. The clear-hawse pendant may still be used, but the preventer hawser must be a good one and must be hove taut. The ship in fact rides by this hawser and not by the clear-hawse pendant, while the chain is slacked for unshackling. Steam should be ready, and an officer should be on the bridge ready to work the engines. By giving a turn ahead from time to time the tension on the hawser can be relieved and there should be no danger in the operation.

All working of chain where unshackling is necessary should be done at slack water or as near it as possible.

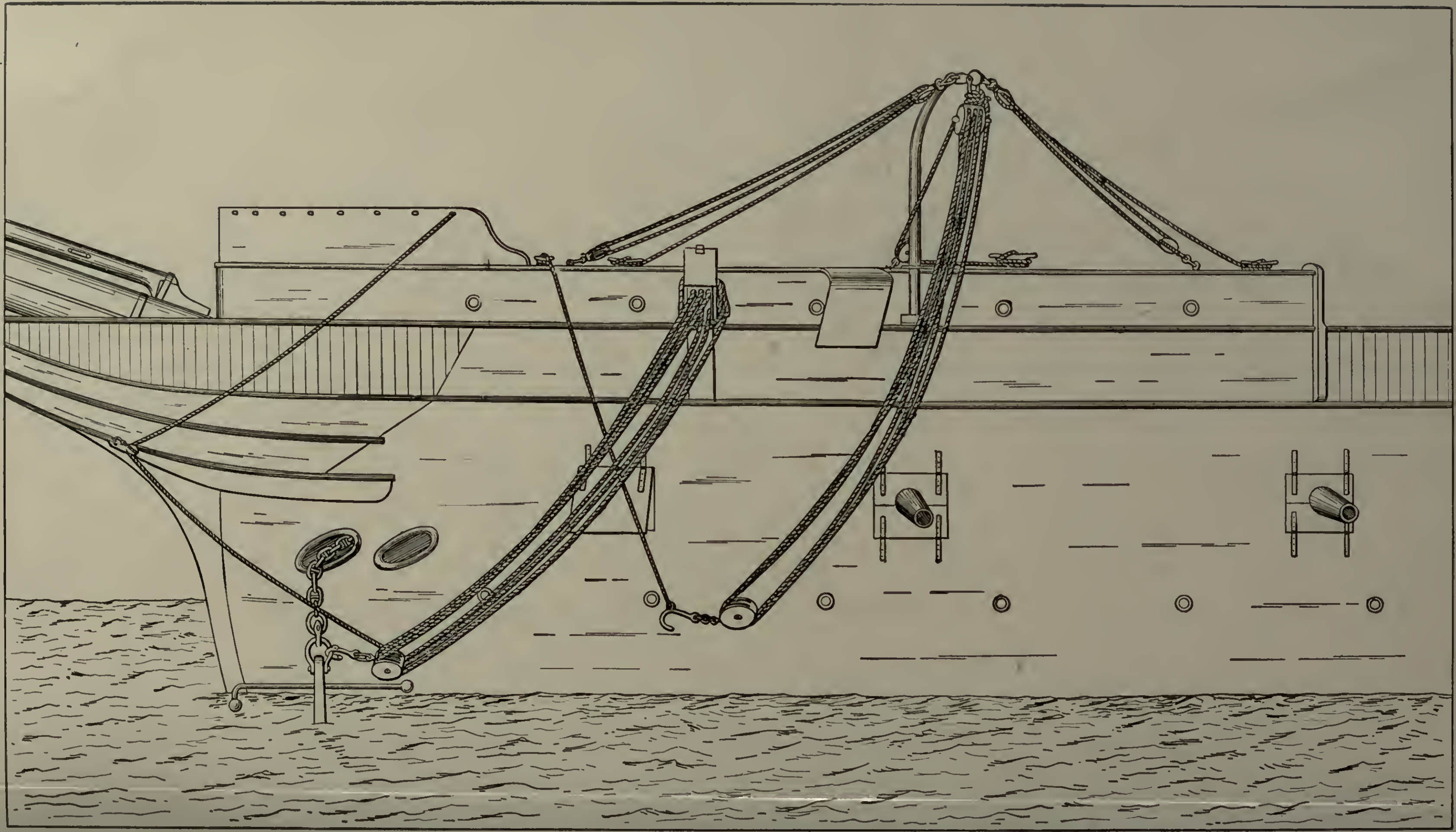
WEIGHING.

In heaving in, the windlass and the cable may be relieved by a judicious use of engines and the helm, and the officer on the bridge should be kept informed of the direction in which the chain "tends" or "grows" on the bow, and whether it is taut or slack.

If there is much tension on the chain when a shackle or swivel comes to the wildcat, there will be trouble from the slipping of the chain, as swivels and shackles are necessarily larger and longer than the links, and cannot take the lugs of the chain-grab so securely. This trouble may always be expected when the depth of water is such that a swivel or a shackle is on the wildcat in breaking ground or after the anchor is aweigh. It may be met by clapping a good line on the cable at once and taking this to the "gypsey" or the capstan. If neither of these is convenient, a deck tackle may be hooked on and well manned. If the drift between the windlass and the locker admits of such a thing, a tackle abaft and below the wildcat is very helpful, tending not so much to relieve the stress as to jam the chain down into its place on the wildcat, and so to prevent slipping. In ships where this difficulty is to be anticipated, it should be prepared for as part of the regular preparations for getting underway. If the controller is as heavy and as strongly secured as it should be, it serves a very useful purpose here in preventing surging, the block being left down so that the chain drops into it, link by link, in coming in. It should be noted that this is quite a different thing from attempting to catch the chain when running out with some velocity. In the present case, the chain cannot slip more than the length of a link and so cannot acquire any considerable momentum.

Shackles and swivels, with the links adjoining them, are, in cables of standard manufacture, made of lengths and sizes carefully proportioned to the rest of the chain and to the cable-holders with which they are to be used. Improvements in this direction

Plate No. 77.



Catting and Fishing Anchor in an Old Fashioned Ship.

and in the design of the cable-holders have greatly reduced the difficulties described above. In cables like the latest ones for the United States Navy, where there is neither a shackle nor a swivel between five fathoms and forty-five, it is impossible for either of them to come to the windlass in breaking ground.

STOWING ANCHORS.

Plate **77** shows the details of handling and stowing the bower anchor of an old-fashioned ship. The anchor being up, and the cat-and-fish overhauled, the cat is hooked and manned. When the chain is ready for surging, the cat is hauled taut, the order given to " surge," and the ring is run up to the cathead, where it is hung by a " ring-stopper," the cat being slacked to let the stopper take the weight. The fish is hooked over the inner fluke (from forward, aft), and the fluke hoisted to the bill-board and hung there by the " shank-painter." If the stock takes against the bow in fishing, it may be canted clear by a " stock-tackle " hooked to a strap on the outer (upper) end, and led across the forecastle. The inner links of the ring-stopper and shank-painter are engaged by tumblers controlled by a single lever. This arrangement admits of releasing both ends of the anchor simultaneously in letting go.

The next step is to " ring up "; viz., to get the ring close up to the cat-head. The cat-fall is unrove, the cat-block gotten out of the way, and the ring-rope, a stout line of proper length with a thimble in the hauling end, is rove through the sheaves of the cat-head and the ring of the anchor and made fast to the shank of the anchor or to the cat-head. A tackle is hooked to the thimble in the inner end and led across the forecastle, and the ring is bowsed up close to the cat-head, the slack of the ring-stopper being taken in at the same time. If the anchor is to be kept in readiness for letting go, it is now left hanging by the ring-stopper and shank-painter with its inner fluke resting upon the outer (sloping) surface of the bill-board. If it is to be secured for sea, the " stock-tackle " is hooked to a strap on the stock, and a " bill-tackle " to a strap on the inner arm, and this arm is roused in-board until the palm overhangs the inner edge of the bill-board. Extra lashings are then passed, on the inner fluke, the shank and the stock. When off soundings, the chain is unbent and the hawse-bucklers closed.

To get the anchor off the bow ready for letting go, the lashings are cast off, the stock- and bill-tackle hooked as before, the arm lifted by an "anchor-bar" to the surface of the bill-board, the shank-painter slacked, and the anchor eased out into place for letting go.

The arrangements for stowing anchors in modern ships differ widely with different types of ships. A number of such arrangements are shown in Plates **78**, **79**, **80** and **81**. A comparison of the figures there given brings out clearly the inconvenience of a stock (as an obstruction to gun-fire) on a man-of-war. This inconvenience is met in some cases by unkeying the stock and laying it along the shank, but this entails both trouble and delay and can hardly be considered a satisfactory solution of the difficulty. In many French, and a few American, men-of-war, the old-fashioned anchors are stowed up and down on the outside of the ship, either in a cradle bolted to the side or in a recess shaped into the plating. This is a clumsy arrangement in itself, and has the serious disadvantage of breaking the waves when steaming into a sea, and throwing great quantities of spray on board.

CATTING AND FISHING IN ONE.

Most anchors, of whatever type, are now fitted with a "balancing link" on the shank, and catted and fished in a single operation by a purchase or pendant from a heavy iron davit, as shown in Plate **80**. This davit turns about a vertical axis, plumbing the proper point of the bill-board at one part of its train and swinging out well clear of the bow at another part.

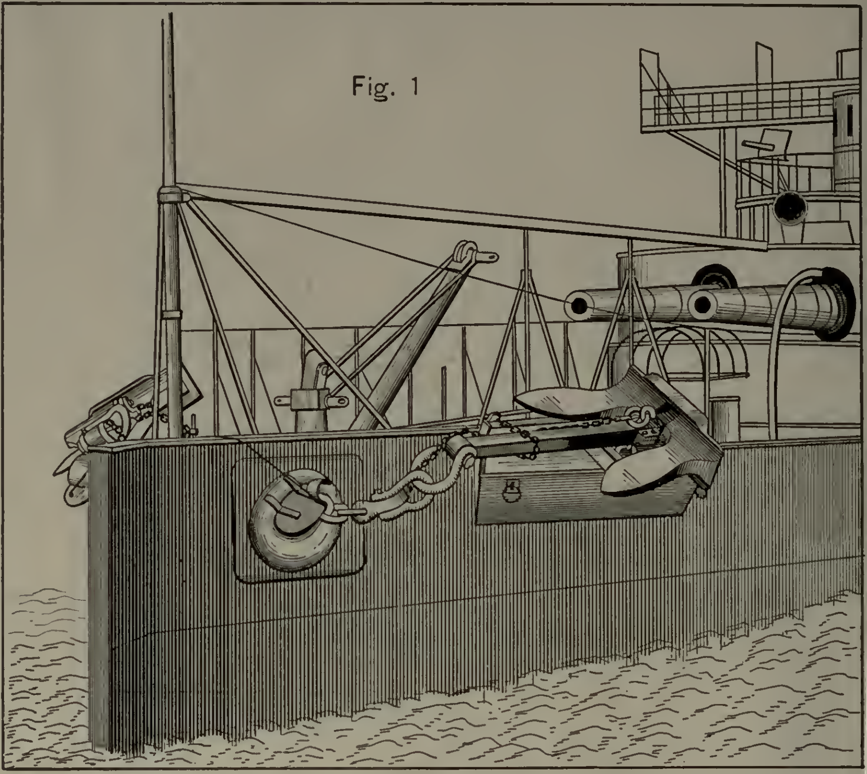
In small ships it is handled by guys, in larger ones by a winch, usually on the deck below. In men-of-war it is hinged to turn down flat upon the deck, out of the way of gun-fire.

At the davit head may be hooked either a heavy single block, swivelled and carrying a pendant, or the upper block of a heavy purchase, usually three-fold.

Where a pendant is used, it leads down to a block at the heel of the davit and then aft. In some cases a thimble is turned in the end and a deck tackle hooked to this, the fall going to a capstan or a winch; in others, the pendant is taken direct to the capstan and the end there made fast, the length being such that there are several turns around the barrel when the cat is hooked and set taut ready for surging chain. The method

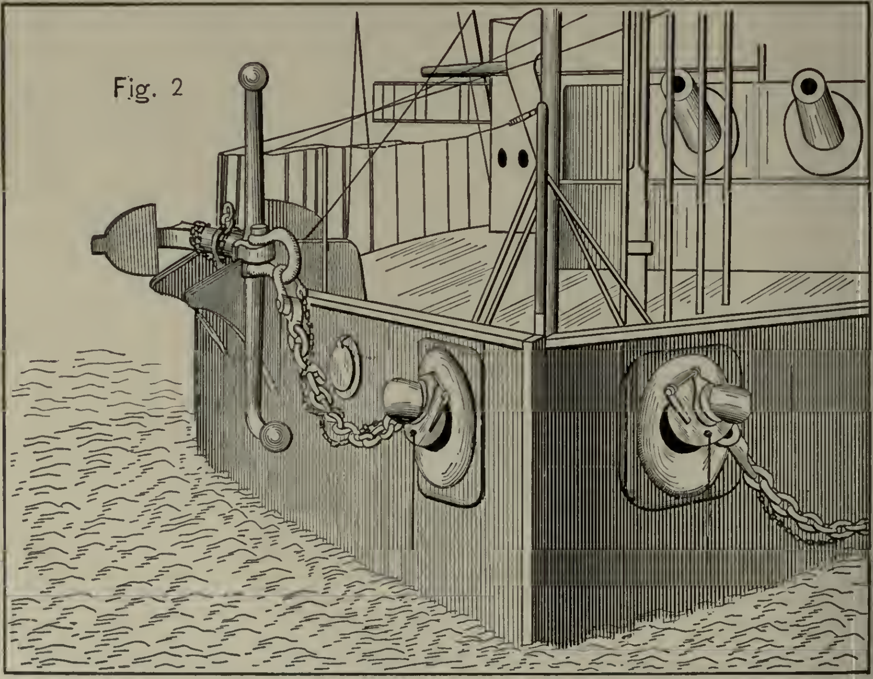
Plate No. 78.

Fig. 1



U. S. S. Puritan

Fig. 2



U. S. S. Amphitrite

STOWING ANCHORS.

Plate No. 79.

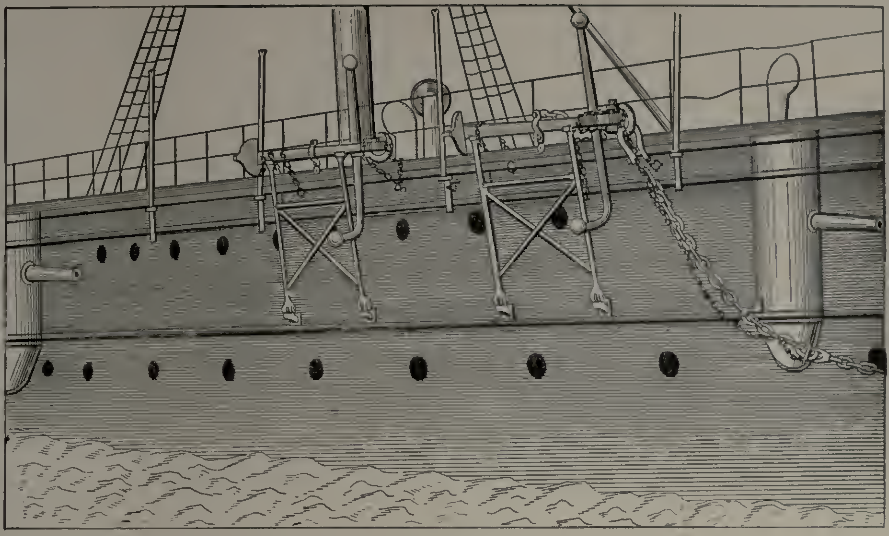


Fig. 1

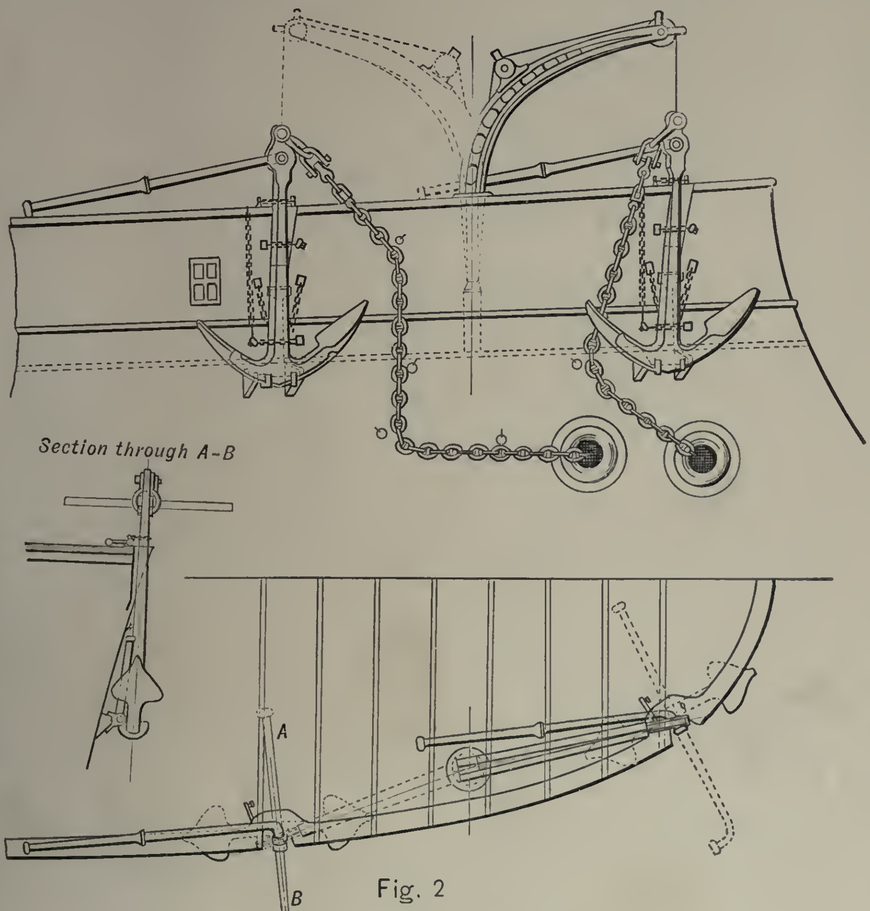


Fig. 2

Stowing Anchors. French Cruiser.

STOWING ANCHORS.

last described is inconvenient and dangerous unless the control of the capstan or winch is on the spar deck at a point from which all details of handling the anchor can be seen. The combination of a pendant and deck tackle is safer and more convenient, but is not without disadvantages. A better arrangement than either of these is the old-fashioned three-fold purchase hooking at the davit head, with the fall leading through a block at the heel and thence to the capstan. This system combines more points of convenience and safety than any of those which have been devised to supplant it, and is coming once more into very general use.

If a pendant is used, it may be either chain or wire. The latter is to be preferred, and for several reasons. It works more smoothly on the barrel of the capstan, and is better adapted, by its elasticity, to stand the sudden jerks which are unavoidable in stowing anchors. For a given size of sheave, a stronger pendant may be used of wire than of chain; and a flaw in wire can be seen at once, whereas in chain it can never be detected until it gives away.

CAT AND GROUND CHAIN.

In ships with ram-bows, the anchor gives much trouble by catching under the ram, and in some ships it can never be hove up directly to the hawse-pipe. To meet this difficulty, there was introduced a number of years ago a pendant in two parts; the outer part, called the "ground chain," being permanently shackled to the balancing link of the anchor and stopped along the chain for several fathoms; the inner part, called the "cat chain," being rove like the ordinary pendant through the block at the davit head. In heaving in, the end of the ground chain comes inside the hawse with the cable to which it is stopped, while the anchor is still below the ram and clear. The end of the cat-chain is taken in through the hawse-pipe and shackled to the ground chain, which is then cut adrift, and the bight is allowed to run out, while the slack is taken in on the cat. The two chains together then form a single pendant to the balancing link, by means of which the anchor is hoisted to the bill-board, swinging out well clear of the ram. A modification of this method consists in using a short ground chain, the end of which comes to the hawse-pipe, but does not go inside. The cat-chain is shackled to this, *outside*, and the anchor stowed as before. In some cases the ground chain is only long enough to reach from the balancing link to the ring of the anchor.

There are very serious inconveniences connected with the use of the ground chain in any form. It is very likely to be torn away from the cable by chafing on the bottom. If the anchor fouls, the ground chain fouls too, and becomes useless when it is most needed. And in nearly all vessels there are other and simpler ways available for clearing the anchor from the ram, or, better yet, to prevent it from fouling. In many cases this may be accomplished by going ahead as soon as the anchor is broken out. The moment the stock touches the ship's side, the wash due to the motion of the ship will tend to turn the flukes parallel to the side and so keep them clear. Going ahead also sweeps the anchor aft, where the lines of the bow are fuller and where the flukes cannot get under the keel. If the helm can be put over to throw the bow away from the anchor, this will help still more. If in spite of all that can be done the anchor fouls the ram, a heavy strap may be put on the cable just above the water's edge and the cat hooked to this. Or a stud may be knocked from one of the links at the proper point and the cat hooked to this link.[1] In some ships the ring of the anchor can be reached when the flukes are under the ram, and the cat hooked in that. The chain is then surged and the anchor swings out clear, hanging from the davit. It is now hove up until past the danger point, when the chain is hove in, the cat slacked, and the anchor allowed to go to the hawse-pipe and to hang there by the chain while the cat is shifted to the balancing link.

Instead of heaving the anchor to the hawse-pipe after it swings clear, it may be hove up to the davit head and hung there by a hawser while the cat is shifted to the balancing link.

The anchor having been run up to the davit head, the davit is trained to plumb the bill-board, straps are put on the flukes and shank, and tackles hooked as necessary, leading fore and aft or athwartships, and the anchor is lowered slowly and landed in its place, where it is secured by the ring-stopper and shank-painter. In securing for sea, extra lashings are passed as may be necessary.

FOUL ANCHOR.

The old-fashioned anchor often comes up with one or more turns of the cable around the stock, the shank, or the flukes.

The conditions here may vary so widely that only very general rules can be laid down for dealing with them. The anchor is

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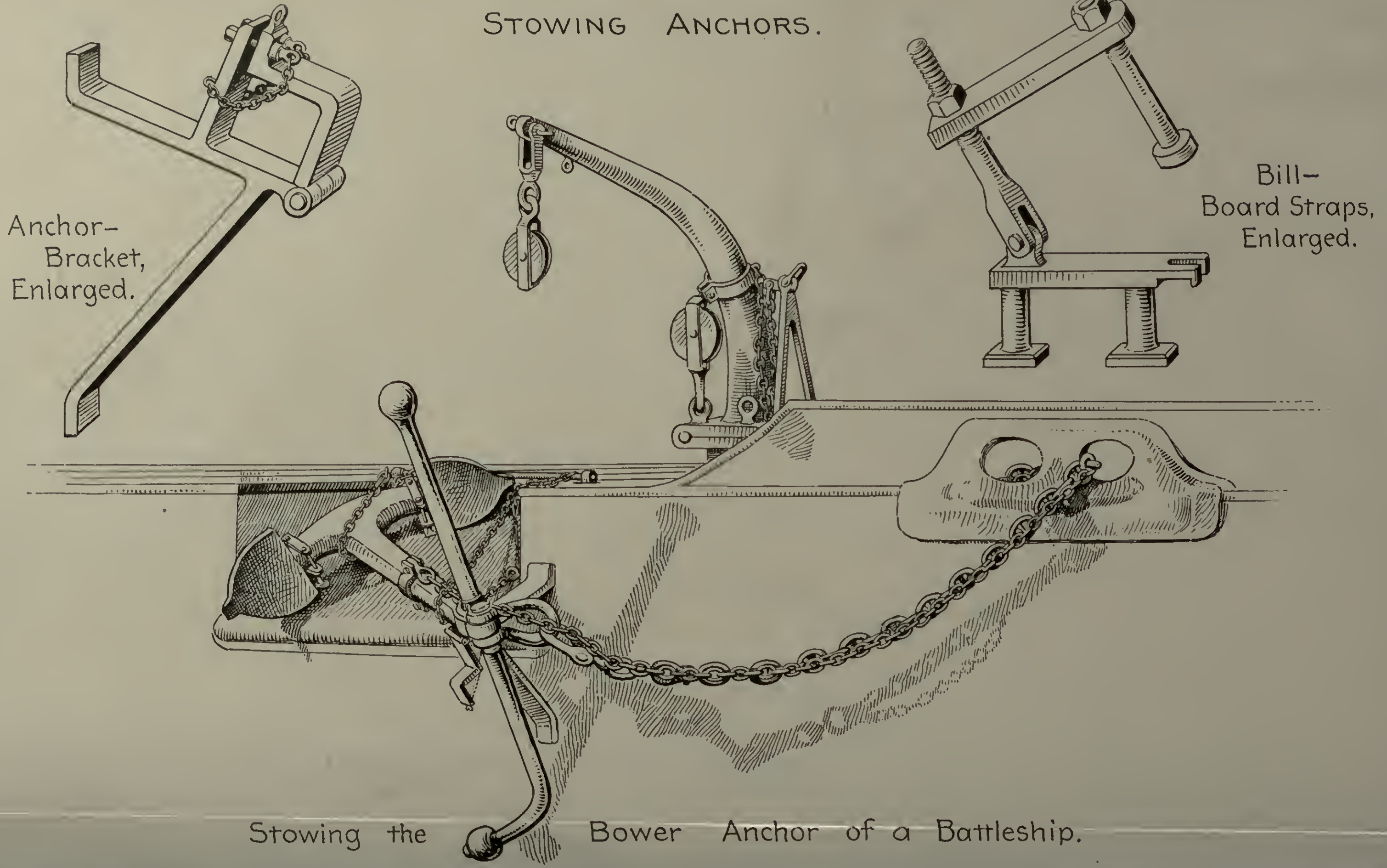
[1] The link is not weakened by the loss of the stud.

Plate No. 80.

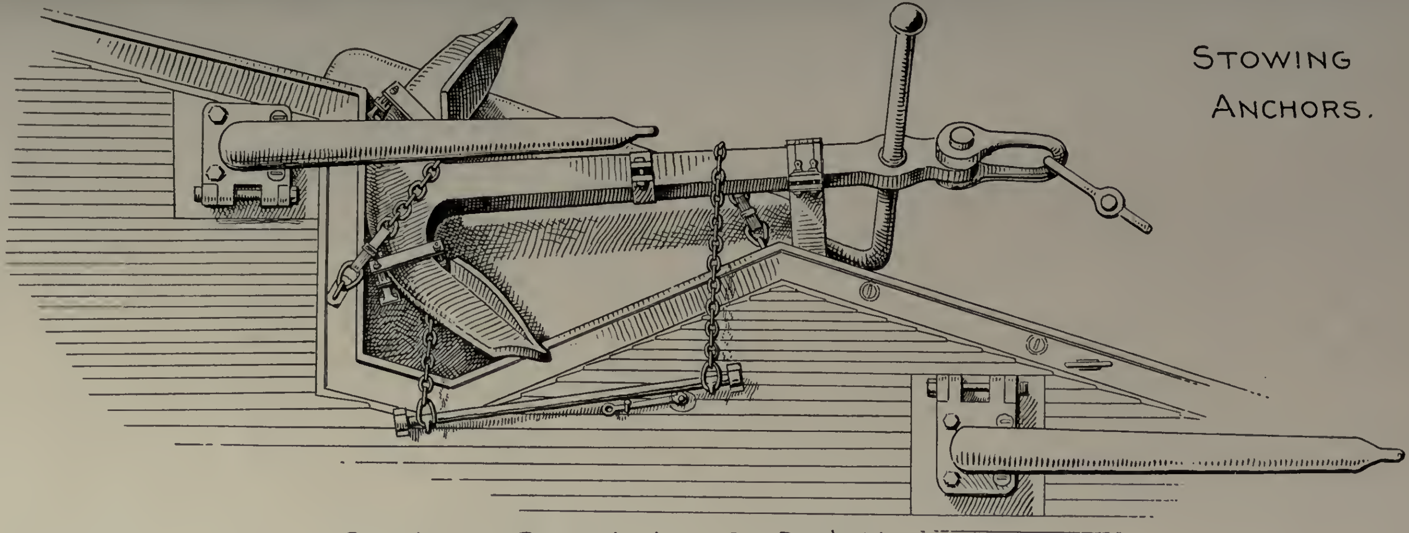
STOWING ANCHORS.



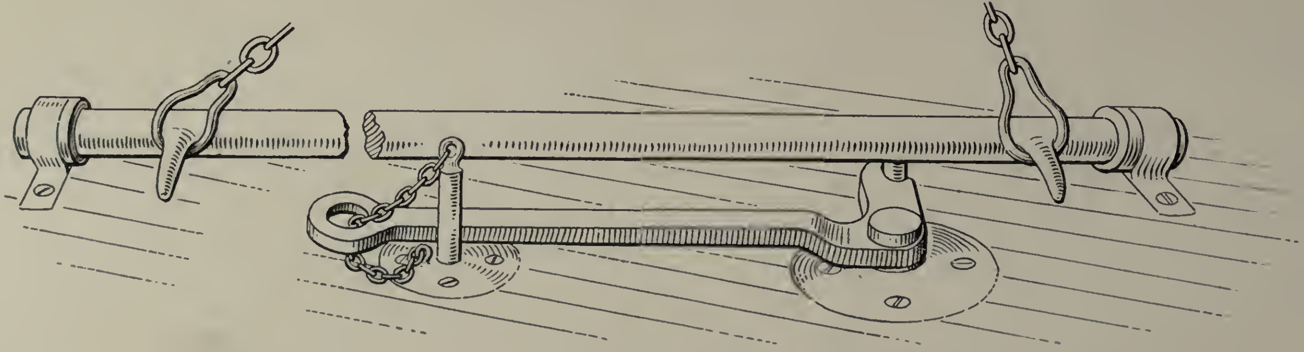
Stowing the Bower Anchor of a Battleship.

Plate No. 81.

STOWING ANCHORS.



Stowing the Bower Anchor of a Battleship.



Releasing Bar, Enlarged.

usually hoisted to the cat-head or davit and cleared by dipping the chain, unshackling if necessary. Slack chain is of course paid out, and the bight is hung by slip-ropes to take the weight. If the cat cannot be hooked in its proper place, it must be hooked to a strap. Slew-ropes on the stock are helpful in clearing the turns.

If the anchor comes up crown first, a strap is used around the arms and shank, and the crown is run up to the davit head. It may be hung there by a hawser, the cat shifted to the balancing link, and the anchor capsized by slacking the hawser and hauling on the cat.

Sometimes a turn around the stock can be cleared by hooking the cat with a turn in the opposite direction to that of the chain, while the anchor is at the hawse-pipe. As the chain is surged and the cat run up, the anchor slews and the chain falls clear.

In all cases of unshackling, a hawser should be secured to the ring of the anchor, as something may give way when least expected. Much labor in lifting and dipping the chain may be saved by the use of two pendants, the anchor hanging by one, as usual, the bight of the chain by the other. The bight being thus held, the anchor is lowered, slewed clear of the cable, and again run up. By this method, *the anchor* is dipped, instead of the chain, and the heavy work of clearing is all done by the winch instead of by hand.

Whenever possible, the anchor should be landed in its place and secured before the work of clearing begins. Where circumstances do not admit of this, it should at least be run well up to the bow and above the rail, where it can be reached conveniently. An anchor bar or small "crow bar" is very handy in opening out the parts of the chain when jammed one upon another.

Perhaps the most difficult case of fouling that can arise is one in which the chain is found hitched around the stock or the arm, with the hauling apart coming out from the inside of a round turn, and with this turn jambed hard upon it. Here it is particularly important to get the anchor close in to the forecastle. The parts may be pried apart a little at a time by means of a small, flat-pointed iron bar, and the hauling part dragged through the bight by a jigger on the end of the stock, the amount gained at each fleet of the jigger being lashed before the strap is shifted for a new pull. In this way, inch by inch, enough slack is accumulated on the bight to admit of lowering it over the end of the stock or fluke, where it will fall clear.

CHAPTER XII.

CARRYING OUT ANCHORS.

1ST METHOD.

The simplest way to carry out an anchor is to hang it from the stern of a launch as in Plate **82**; but this utilizes only a small part of the floating power of the boat and is not practicable with a heavy anchor. The floating power may be considerably increased by buoying the stern with casks, as in Plate **83**, and it is a good plan to keep a few casks fitted with slings for this purpose.

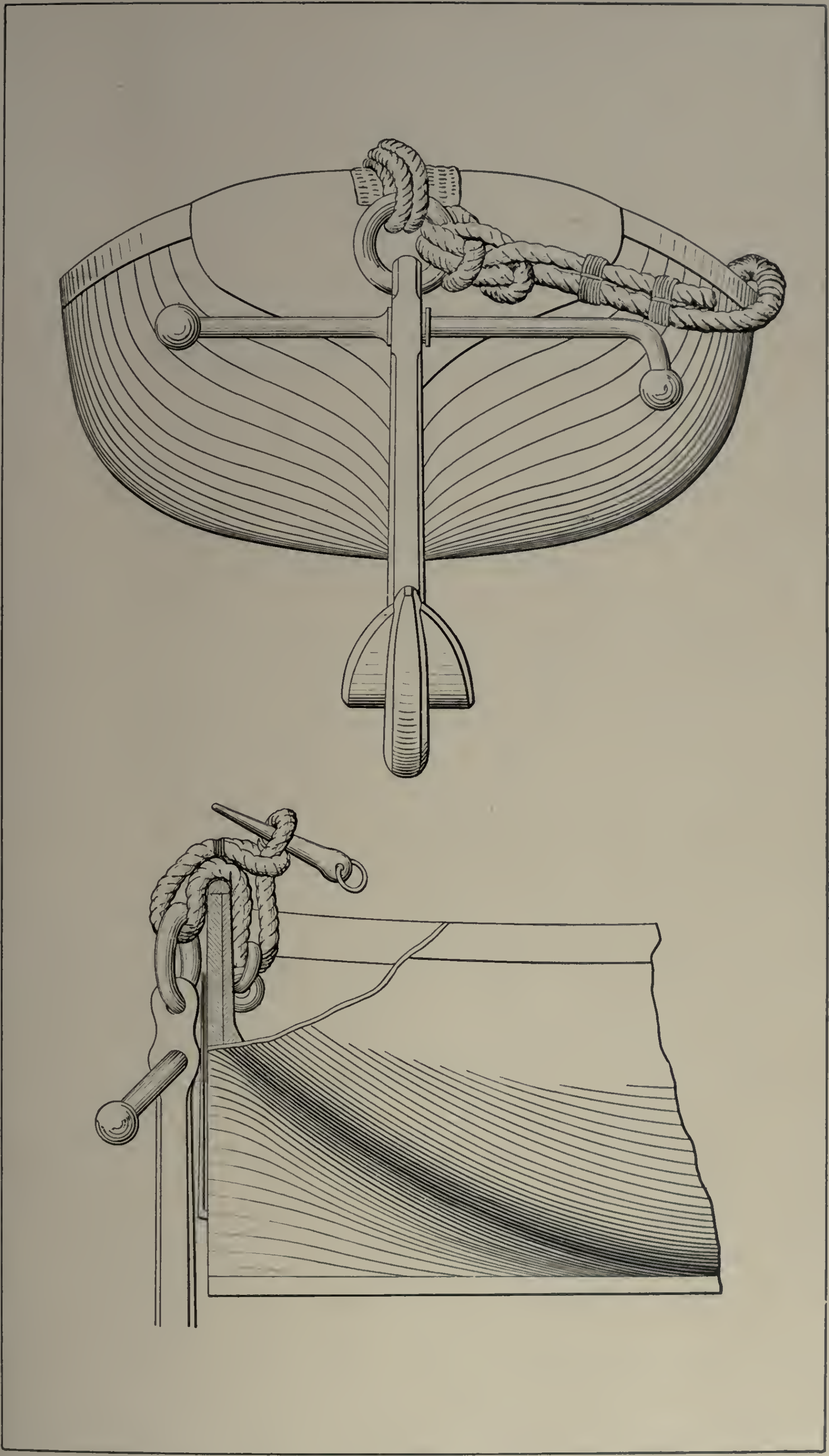
On men-of-war, a certain number of casks are kept in the hold, filled with fresh water, and slung, ready to be hoisted out quickly and put in boats in the event of abandoning ship. The slings may be fitted in such a way that these casks shall be available for buoying the stern of a boat—the water being run out and the bungs re-driven.

The anchor is lowered by a purchase hooked to the ring, and hung by a good strap passed around the shank under the stock with both ends brought inboard through the stern ring-bolt and secured in any convenient way for cutting or slipping.

If laying out a kedge and line by this method, the line may be coiled in the boat and paid out from the anchor to the ship, or a short length only may be taken in the boat and the rest paid out from the ship as the boat pulls away. In all cases where the line is carried in the boat, enough of it must be thrown over before letting go to make it certain that the anchor will reach the bottom with plenty of slack to spare.

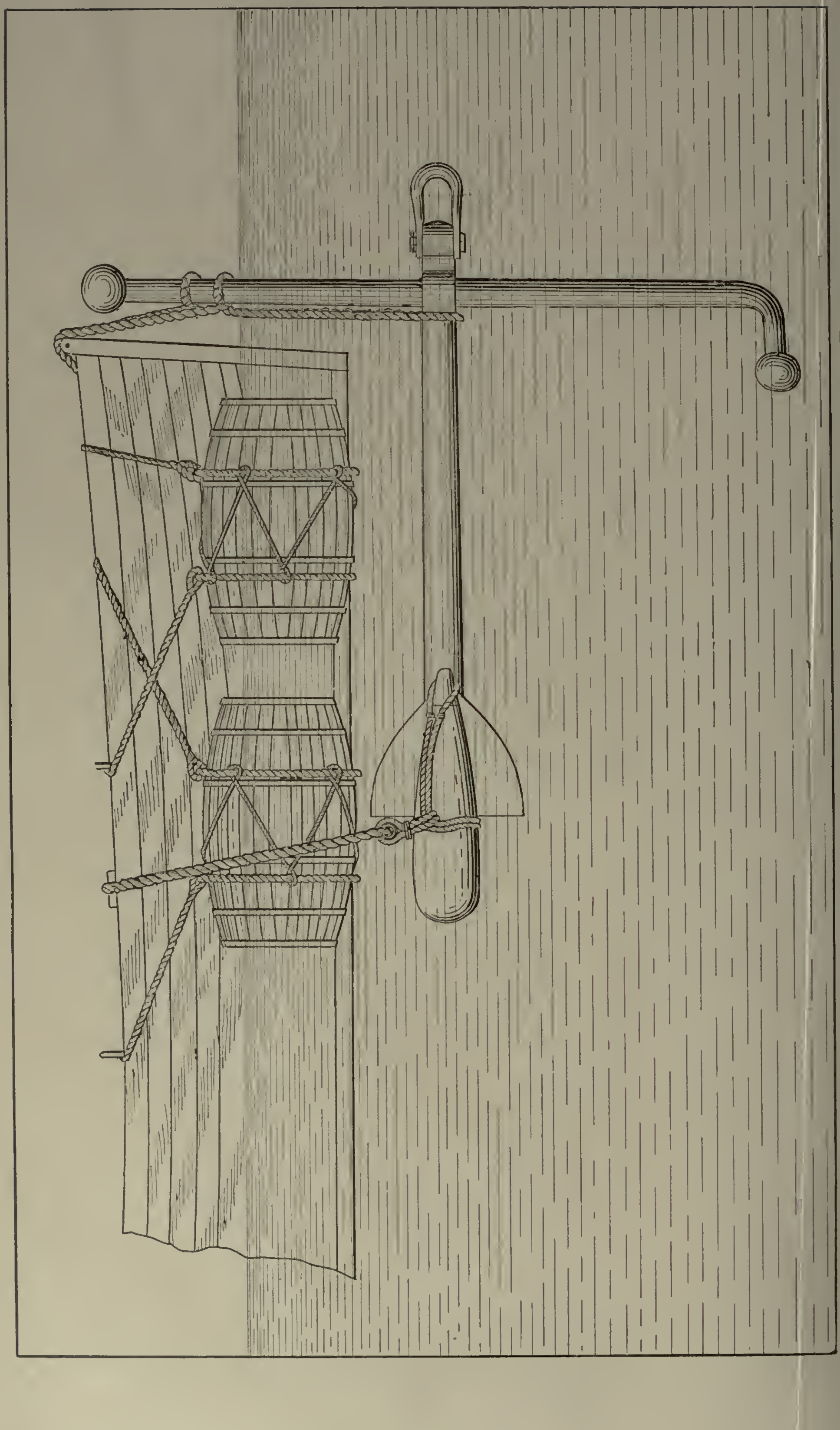
If a length of chain cable is to be taken out with the anchor, it should be stopped up around the sides of the boat outside, and the stops should be cut before letting go. If there is too much chain to be stopped around the boat in this way, some of it may be faked down in the boat, but this should be thrown over before letting go, being held up outside by slip-stoppers if there are reasons for not heaving it over altogether before the anchor is dropped.

Plate No. 82.



CARRYING A KEDGE WITH A CUTTER.

Plate No. 83.



CARRYING OUT AN ANCHOR UNDER STERN OF A BOAT.

(STERN BUOYED BY CASKS.)

2ND METHOD.

Where the anchor is too large to be hung from the stern of the boat, the arms may be slung under the bottom, as in Plate **83**. Two large thimbles are spliced into straps and clapped on the arms of the anchor just inside the flukes. Through these is rove a stout line, long enough to come in over the rail on each side, and with an eye in each end for a toggle. Two straps are put on the shank and stopped up to the stock;—one a long one for securing the anchor at the stern of the boat, the other a shorter one for hooking a tackle to lower. A strap for another tackle is passed around the inner arm. In an old-fashioned ship with a cat and fish, the cat is hooked to the strap at the stock, and the fish to that on the inner arm. In modern ships, only a single purchase is provided for handling the anchor; so if this method is to be used, it will be necessary to improvise some plan for rigging the extra purchase. The anchor is lowered under water and the boat hauled in over it with the stern against the stock, the stock-lashing is brought in over the stern, the lines from the arms are led in on each side over the gunwale, and all are secured for cutting or slipping. It is important in letting go that all lines should be slipped together, and this is difficult to ensure unless they are made fast in such a way that they can be released by a single act.

3RD METHOD.

Where a launch is available fitted with a trunk and windlass,[1] an old-fashioned anchor may be handled as in Plate **84**. Here the stock is hung from the stern and the arms are hove up under the bottom by a rope from the upper fluke led through the trunk and taken to the windlass.

The plate shows a convenient plan for hanging the anchor and letting it go. The line for slinging the crown is made fast on the bight and both ends are brought up through the trunk. One end, A, is the "windlass" rope, the other, B, the "letting go" rope. In the same way, the line at the stock is double, one end, C, being used for getting the stock in place, the other, D, for letting go. The anchor having been hove up close to the bottom of the boat and hung there by A and C, the ends of B and D are brought together and lashed, after which the windlass is walked back until the lashing has the weight, when A and C are cast adrift altogether. Before cutting the lashing to let go, A should be stuck out through the trunk and C thrown out over the stern. For reeving the lines A and B through the trunk, a light line is bent to a boat-hook which is then shot downward through the trunk. It will rise alongside the boat bringing the end of the line.

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[1] All sailing-launches of the United States Navy are fitted with a trunk and windlass. A composition cap, which can be screwed on or off while the trunk is shipped, closes the hole in the bottom when the trunk is not in use.

With a boat fitted in this way, a patent anchor may be slung by the balancing band from the windlass and thus carried out with the whole weight under the center of flotation of the boat. Steadying lines would in this case be bent to the flukes and brought in over the rail on each side.

4TH METHOD. (Plate **85**.)

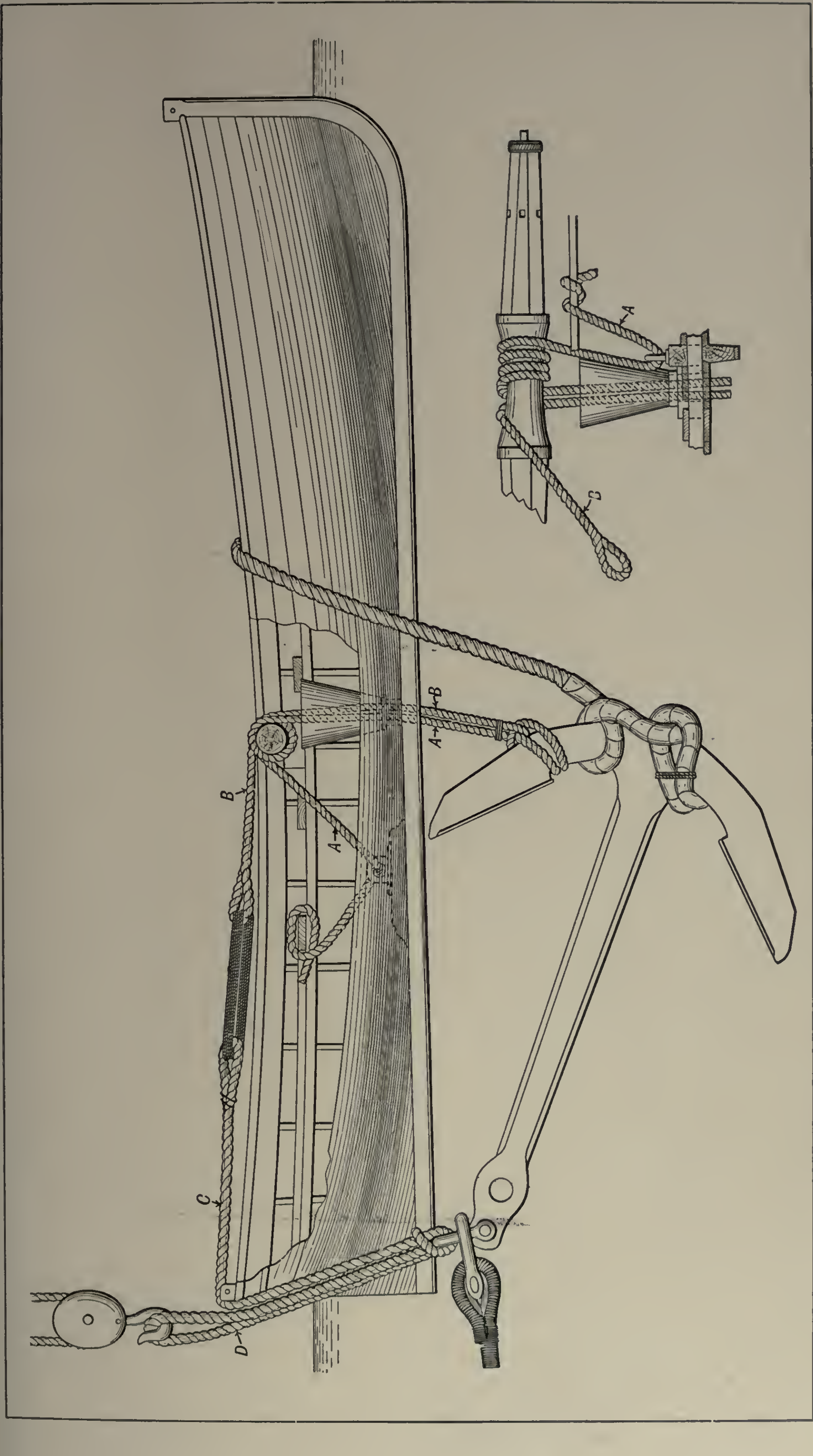
This method is used in the English Navy, and straps are issued to ships, fitted and ready for use. Where such straps are not supplied, there should be no difficulty about fitting them on shipboard. The straps A and B are passed around the boat and toggled while preparations are in progress for lowering the anchor, and the end of C is hauled up to the water's edge ready for hooking on. A "spreader" is used to relieve the crushing strain on the gunwale. The anchor is lowered by the fish tackle, and C is shackled to the balancing band. Upon lowering away, the anchor swings into place below the keel. This method has the great advantage that it carries the anchor under the center of flotation of the boat and that only one strap has to be released for letting go. It has the disadvantage that it cannot be used in shallow water. Another possible disadvantage is that there may be trouble about unhooking the block of the fish tackle so far below water.

The drawing shows this method applied to a stockless anchor, but there is no reason why it should not be used with the old type, steadying lines being bent to the stock and flukes and brought in over the rail on each side.

5TH METHOD. (Plate **86**.)

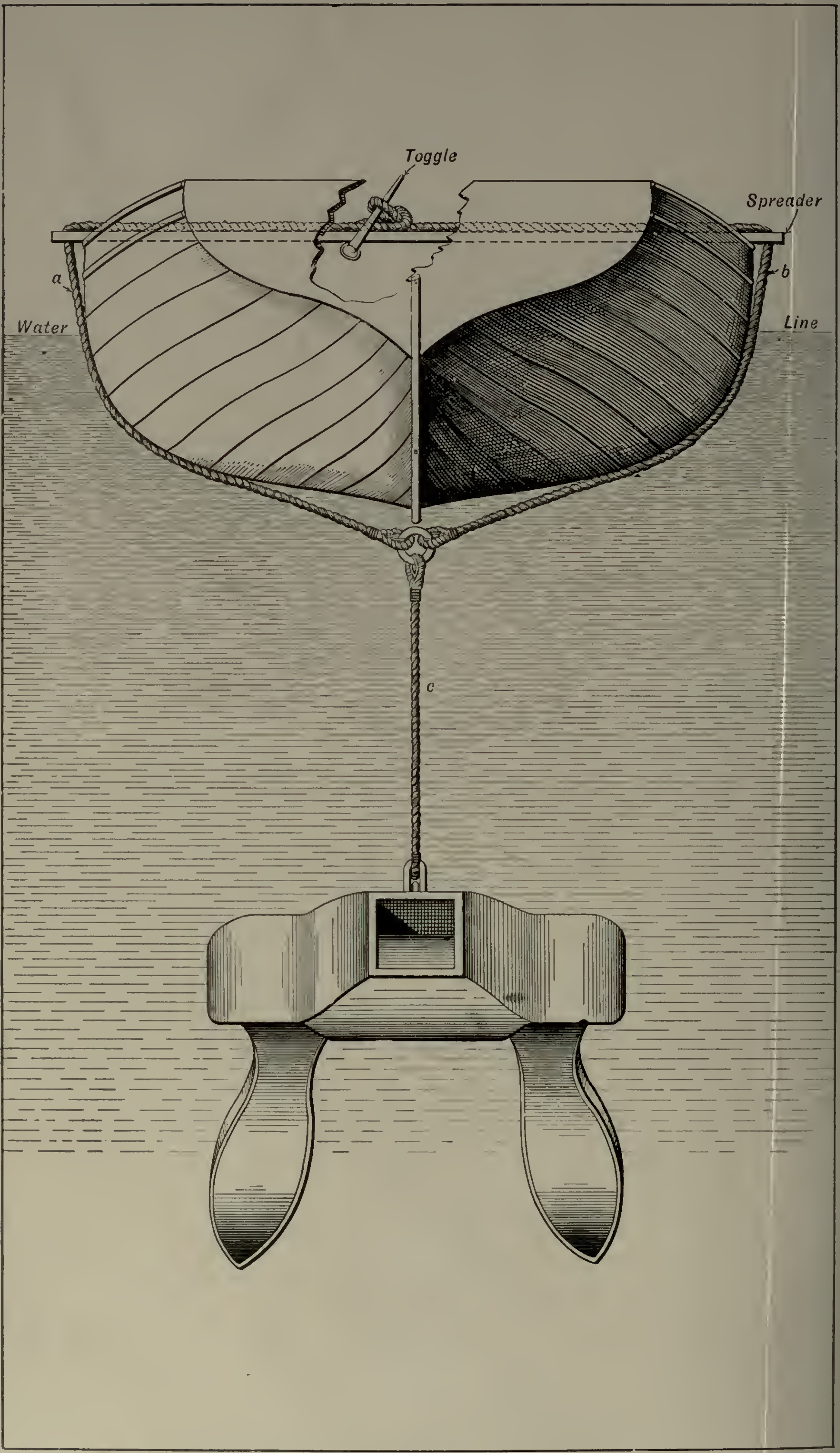
This method somewhat resembles the preceding, but with important points of difference. A single strap, fitted with lashing eyes, is passed around the boat and brought in over a

Plate No. 84.



CARRYING OUT ANCHOR WITH LAUNCH FITTED WITH A TRUNK.

Plate No. 85.



CARRYING OUT AN ANCHOR SLUNG UNDER A BOAT.

spreader. The eyes are lashed (or toggled) together, leaving the strap *slack* below the keel. On the strap is fitted a traveller, consisting of a thimble with two stout tails, which is kept at the water's edge. The anchor is lowered by the fish tackle until the tails of the traveller can be passed through the balancing link and around the shank. Upon easing away the fish tackle the traveller slips down the strap until it hangs from the middle of the bight below the keel.

Here we have the same advantages as in the preceding method, with some gain in the depth of water required and in convenience of rigging. It is found that if the strap is passed taut around the boat there is a chance that the traveller will not slip down freely to the middle of the bight, and may list the boat. Where the bight hangs a foot or so below the keel, this difficulty cannot arise;—the traveller slipping freely down without causing any appreciable list.

The stock and flukes can be slewed into any position that is found advantageous, by means of the steadying lines.

As there might be some difficulty about unhooking the block of the purchase under the bottom of the boat, a strap and toggle may be used as shown in the plate. As the strap will be slack when it is desired to unhook, there can be no difficulty about hauling out the toggle by its lanyard. This plan is evidently available also for unhooking the strap in the 4th method.

6TH METHOD. Two Boats (Tandem).

Where two boats are to be used, the simplest and quickest method is that of Plate **87**, but this utilizes only a small part of the floating power of the boats. Something can be gained in this respect by putting weight in the opposite ends.

This is distinctly a shoal water method, although it may of course be used in any depth.

7TH METHOD. Two Boats (alongside).

Two boats may be secured together as in Plate **88**, with two spars crossing from the outer gunwale of one to the outer gunwale of the other. The anchor is hung between these spars and let go by cutting a lashing which drops both ends at once.

A third spar lashed across from stem to stem prevents the bows from drawing apart and furnishes a point to which a line may be made fast for hauling out to a kedge, this line being taken through a block on the ring of the kedge and led back to the ship, where it is manned.

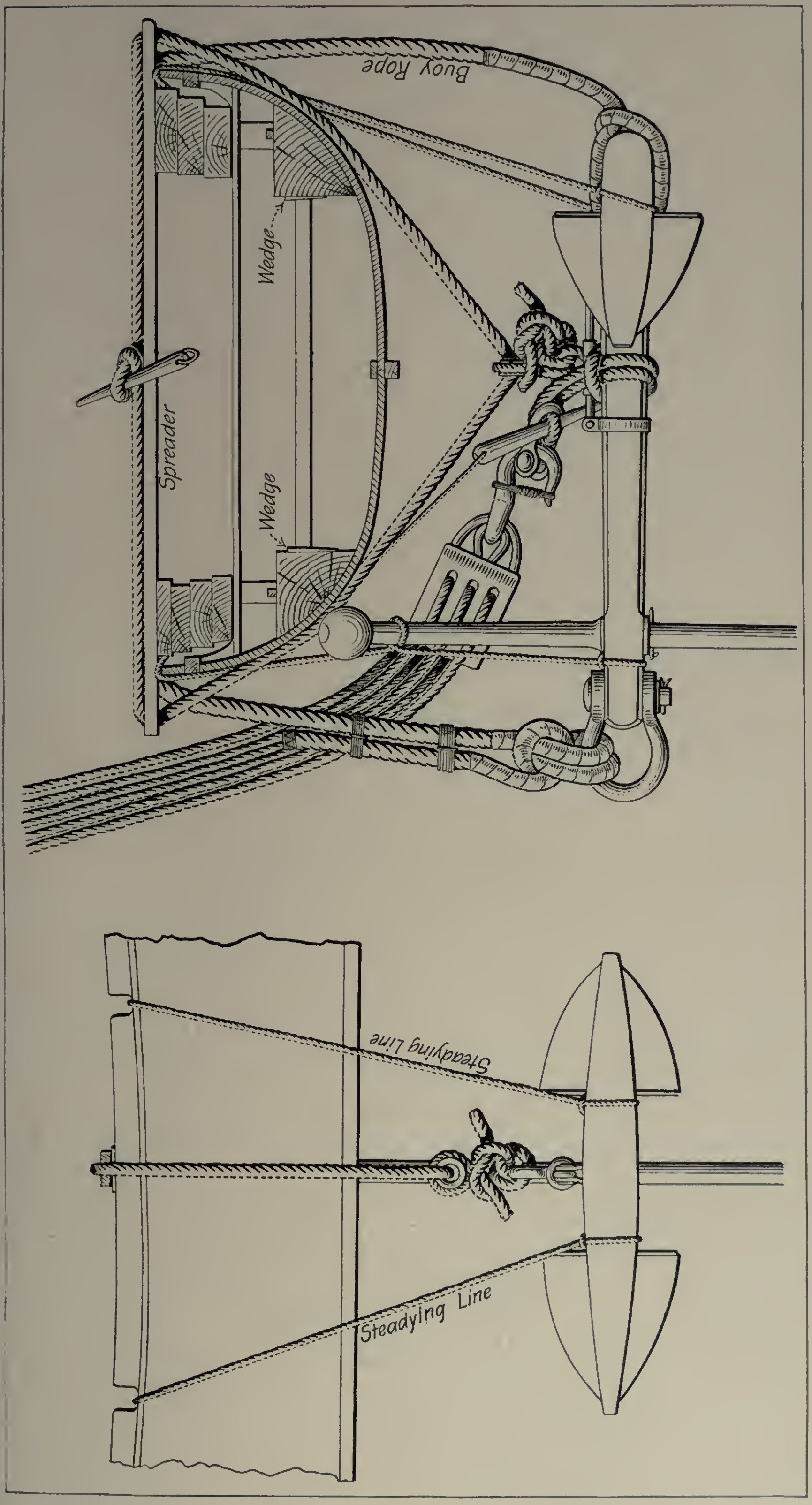
In this method, everything having been prepared for lashing the boats together, the anchor is lowered well under water by two tackles, one of which is hooked in the ring, the other to a strap around the upper fluke. The boats are then hauled in on each side of the tackles and lashed together, the stock and fluke of the anchor are adjusted at the proper height, and two straps are passed as shown in the figure and lashed or toggled together. If it is inconvenient to rig two purchases, a strap may be clapped on the shank of the anchor near the balancing link, *but on the side of the shank in the plane of the flukes*, so that when the weight of the anchor is taken on this strap the stock shall hang horizontally. It is well also to sling the anchor a little stock heavy. The fish tackle is hooked into this strap and two light jiggers from the davit head hooked to other straps, one around the shank and stock, the other around the upper fluke. The anchor is then lowered as before, the boats hauled up and lashed together, and the stock and fluke are adjusted as to height by the jiggers.

If the water is rough under the bow, the stock should be kept deep enough to prevent the boats from striking it as they thrash about.

This method perhaps combines more points of advantage than any other that has been suggested. It utilizes the full floating power of two boats, and admits of letting go by cutting a single lashing. As the two boats are brought close together, they can be secured rigidly enough to act almost like one.

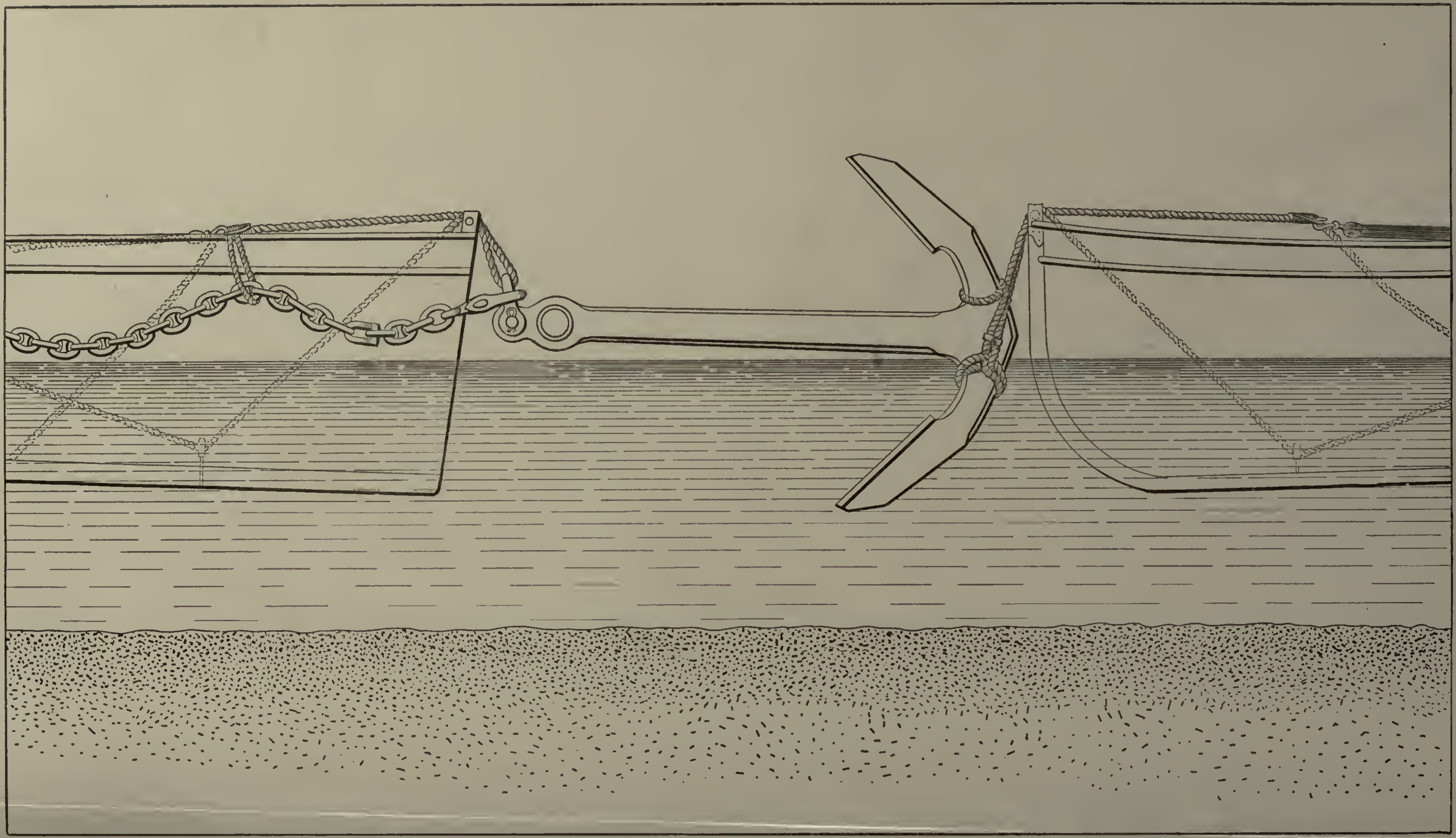
Whatever method is used for floating the anchor, the boat or boats employed should be hauled out to the place where it is to be dropped, by a line made fast to a kedge; the kedge being planted and a line brought back to the ship while the anchor and the launch are being prepared. Under ordinary circumstances, a single line is used and the men in the boat haul out; but if the anchor is a very heavy one, and especially if the weather is rough, a large single block should be lashed to the ring of the kedge and a line rove through this, both ends being brought back to the ship and one of them manned on board, while the other is made fast to the bow of the boat from which the anchor hangs.

Plate No. 86.



CARRYING OUT AN ANCHOR. 5th METHOD.

Plate No. 87.



CARRYING OUT A HEAVY ANCHOR IN SHOAL WATER
BETWEEN TWO BOATS (TANDEM.)

The anchor must be slung with its crown toward the bow of the boat, so that, after hauling out to the place for letting go, the stock shall be toward the ship. The kedge for hauling out is of course placed a little beyond the point where the anchor is to be dropped.

It is often very difficult to handle a boat under the bow; as, for example, when there is a heavy sea running, or a strong current. Under such circumstances a light kedge may be laid out to windward—or where it will best answer the purpose—and the boat controlled by a line from this with one or more lines to the ship.

In cases where for any reason boats cannot be used, it may be possible to float an anchor by a raft of casks and spars, and to haul this out to a kedge. This of course supposes that a boat of some kind is available for planting the kedge, but it may be only a small one, such as would be wholly inadequate for floating a larger anchor.

§ II. CARRYING OUT A CABLE OR HAWSER.

It is seldom necessary to carry out a chain cable with an anchor, a good hawser being in most cases very much more useful. On a rocky bottom, it is well to use a length of chain next the anchor, bending the hawser to this. Of course there may be cases where chain is to be preferred for the whole length; as for example, where the conditions are such that the anchor-windlass can be used for heaving.

When more than 15 fathoms of cable is to be carried out, it is usually best taken in a separate boat, which may, however, tow out astern of the boat carrying the anchor. The cable should be stopped up around the outside of the boat, not ranged inside; and before letting go, the stops of the chain should be cut until a length of slack chain is hanging free, sufficient to much more than reach the bottom. If a second boat is following with chain to be shackled to that already on the anchor, the two parts should be shackled before the anchor is let go, the bight being hung clear of both boats, outside, by slip-stoppers.

Where a considerable length of chain is to be used, the end of the first length may be buoyed and the boat hauled back to the ship to receive the remainder of the chain, which may in this case be ranged inside, with the shackling end clear and with good check stoppers at frequent intervals. The end of the first length having been recovered, the new length is shackled on and the boat hauled very slowly back toward the ship, paying the chain out link by link and using every care to prevent its taking charge.

Shackling tools go in the boat in all anchor expeditions.

By using several boats in a single tow, the cable may be laid out from the ship, the first boat running away with the end (and the anchor) and the other boats coming under the bow in succession, at intervals of fifteen or twenty fathoms, and hanging the bight of the chain by slip-stoppers from their bow and stern. This demands good power for hauling out.

Where a hawser is used, it may be coiled in the boat; but in this case, as in all others, care should be taken that a sufficient length to reach the bottom is thrown over before letting go—the depth of water being ascertained by sounding. The anchor having been let go, the boat is hauled back to the ship, paying out line as she comes.

Another way is to run the line like a guess-warp as the boat hauls out, heaving over all that remains in the boat just before letting the anchor go. The objection to this is the danger of fouling the anchor by the slack line paid down at the last.

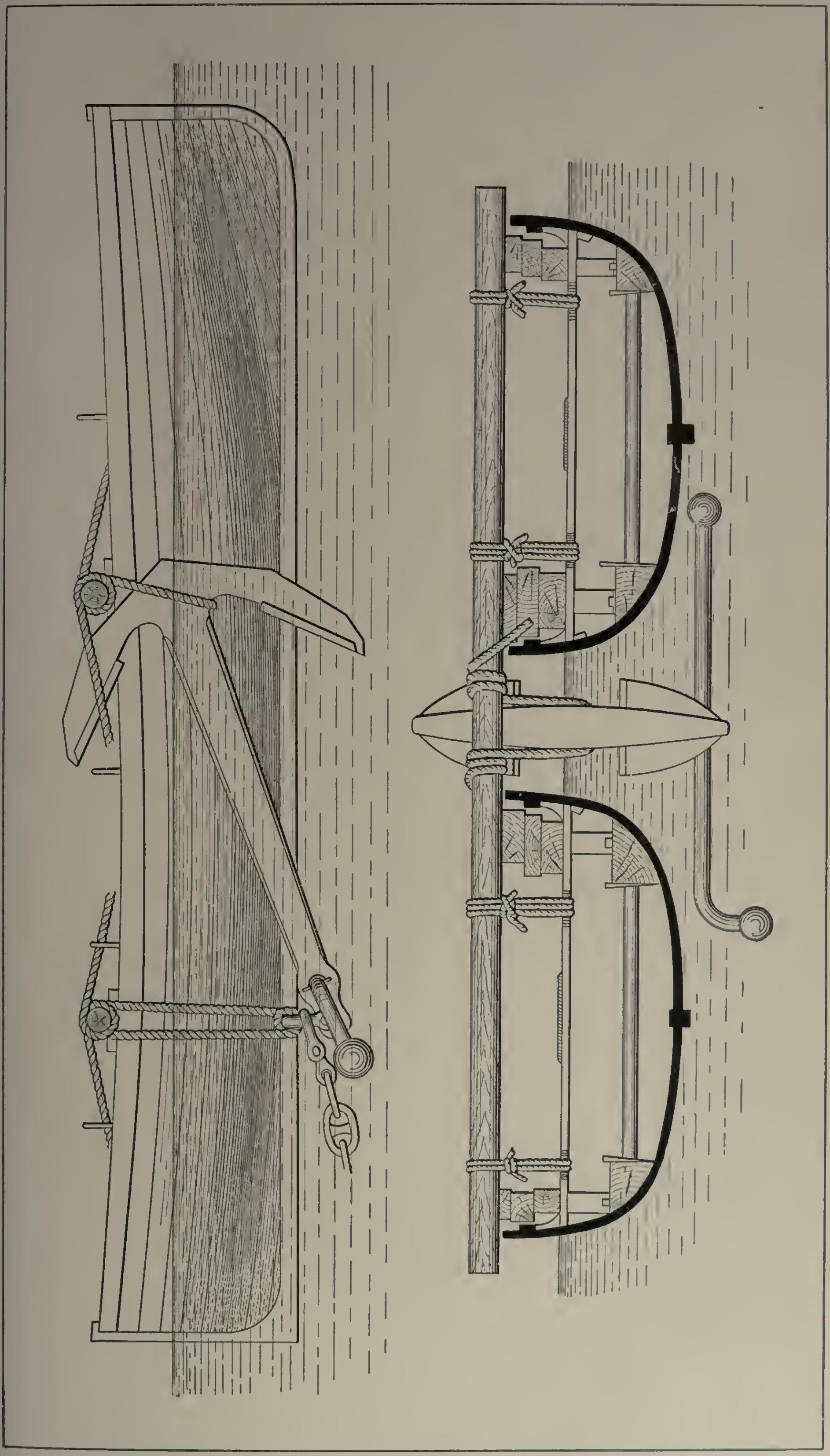
§ III. TABLES.

WEIGHTS OF ANCHORS FOR SHIPS OF VARIOUS DISPLACEMENTS.

(U. S. NAVY.)

Displacement.	Bower or Sheet.	Stream.	Kedge.	Kedge.	Kedge.	Kedge.
Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1000	2750	688	458	344	275	....
2000	4500	1125	750	562	450	....
3000	6000	1500	1000	750	600	....
4000	7000	1750	1000	875	700	500
6000	9000	2250	1285	1125	900	643
8000	10000	2500	1428	1250	1000	714
10000	12500	3125	1785	1563	1250	893
12000	13500	3375	1928	1687	1350	964

Plate No. 88.



CARRYING OUT AN ANCHOR BETWEEN TWO BOATS.

APPROXIMATE WEIGHTS OF STUD-LINK CHAIN.

Diameter.	Weight of one fathom.
(Inches.)	(lbs.)
½	16.5
¾	30.31
1	55.16
1¼	90.40
1½	130.69
1¾	176.98
2	234.48
2⅛	263.40
2¼	2.76
2½	3.36
2¾	4.06

APPROXIMATE WEIGHTS OF MANILA AND WIRE HAWSERS.

Circumference.	Weight of one fathom.	
	Manila.	Wire.
(Inches.)	(lbs.)	(lbs.)
2	2	3
3	3	7
4	4	12
5	6½	24
6	9	33
7	12	41
8	15	53
9	19	65

TO FIND THE FLOATING POWER OF CASKS.

Rule: Multiply the number of gallons of the cask by 8 if counting in American gallons, or by 10 if counting in English (Imperial) gallons. The result is the floating power in pounds.

The weight of the cask itself when immersed will be immaterial.

Attention has been called to the fact that where an anchor is hung from the stern or under the after part of the boat, the proportion of the total floating power which is utilized is much less than one-half.

To determine roughly what this proportion is, the following experiment was made:

Boat used, a United States Navy Cutter (square stern) of the following dimensions:

Length over all, 28 ft.
Beam, 7 ft. 5 inches.
Depth, 2 ft. 8 inches.
Freeboard amidships (empty), 24 inches.
Freeboard at stern, 40 inches.

1st. The boat was loaded with men (average weight about 150 lbs.), distributed uniformly throughout until the least freeboard was 12½ inches.

No. of men, 56.
Weight, 8400 lbs.
Freeboard amidships (to bottom of rowlocks), 12½ inches.
Freeboard at stem (to upper edge of rail), 36 inches.
Freeboard at stern (to upper edge of rail), 22 inches.

2nd. Men were grouped in the after part of the boat, the center of the group being 2 feet from the stern post. No other men in boat.

No. of men at stern, 17.

Weight, 2900 lbs.

Freeboard at stern, 14 inches.

Freeboard amidships, 20 inches.

The bow was raised high out of water, the keel showing for fully one-fourth of its length from the forefoot. It would be impracticable to use the boat in this trim.

3rd. Twelve men (1800 lbs.), representing the crew of the boat, were placed in the bow, the men in the stern being left there as above described. This changed the trim as follows:

Freeboard at stern, 25 inches.

Freeboard amidships, 20 inches.

Freeboard at stem, 40 inches.

This shows very strikingly the increase of flotation at the stern due to the addition of weight in the bow. This is a more convenient and more effective method of increasing the flotation than to use casks under the counter. It must not be overlooked, however, that as the anchor is let go, the bow will dip, unless the weight can be quickly distributed. This is the great advantage of using men rather than chain or other dead weight.

CHAPTER XIII.

THE STEERING OF STEAMERS.[1]

§ I.

The elements which enter into the steering of a screw steamer are so many, and their effects are so varied and conflicting, that any attempt at an exhaustive analysis of them would be altogether out of place in a work on practical seamanship. It is proposed here merely to name and briefly discuss the most important of them and to explain such of their effects as enter practically into the handling of a ship. In this discussion it will be assumed, where not otherwise stated, that all conditions are normal and average; that is to say, that the ship is of medium size and draft and loaded to her mean water-line; that she has no unusual features of design; that she draws rather more water aft than forward; that her rudder is of the ordinary type and of medium size, and fitted to a rudder-post immediately abaft the propeller-well. It will be assumed also, except where the contrary is stated, that the weather is calm.

For simplicity, the discussion will be confined to a right-handed screw, so that all which is said of the effects of the screw upon the steering must be exactly reversed for a vessel with a left-handed screw.

Twin-screws will be treated in a separate section.

The factors which we shall consider as entering into the steering of a steamer are the following:

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[1] See "The Steering of Steamers" by Professor Osborne Reynolds, in Report British Association, 1875; Reports of the Committee on the "Effect of Propellers on the Steering of Vessels" in Report British Association, 1876, 1877; "A few years' Experience of the Screw Propeller" by Arthur J. Maginnis, in Proceedings Institution of Naval Architects, 1879; "The Steering of Ships," Chapter XVIII, White's Manual of Naval Architecture; "The Effect of Reversing the Screw Propeller upon the Steering" by Captain John Bain in Proceedings of Institution of Engineers and Shipbuilders in Scotland, 1893-94.

1. The ordinary direct influence of the Rudder.

2. The Screw Current,—which we shall find to be made up of two distinct parts.

3. The Force exerted by the revolving blades of the Screw to drive the stern to one side or the other by their direct Sidewise Pressure upon the water.

4. The Wake Current.

1. The Rudder.—The effect of this is simple and well understood. It calls for no explanation here, except in so far as it is complicated by the screw current, in connection with which it will be fully treated below.

2. The Screw Current.—As the screw turns, it draws in a current from one direction and forces it out in the other. In going ahead, the current is drawn in from forward and forced out aft. In backing, it is drawn in from aft and forced out forward.

It is found that the in-rushing "suction" current may be considered as flowing parallel to the line of the shaft, but that the current driven off from the screw partakes to an important degree of the rotary motion of the blades and moves diagonally to the shaft and keel.

(a) If the screw is turning ahead, the inflowing suction current from forward moves along the lines of the run toward the screw and has no appreciable effect upon the steering.

It is different with the outflowing current thrown off and driven aft by the screw. This current, by reason of the rotary motion which has been referred to, strikes diagonally upon the rudder-post and the rudder (which we will for the moment suppose to be amidships) and exerts a distinct force tending to throw the stern to one side. We must recognize here, however, two factors opposing each other. The upper blades of our right-handed screw move over from port to starboard and drive their current against the port upper side of the rudder-post and rudder. At the same time, the lower blades drive in their current upon the starboard lower side. As the lower part of the rudder is commonly larger than the upper part, it is natural that the current from the lower blades, tending to drive the stern off to port, should more than overcome that from the upper blades, and that the resultant of these two forces should tend, upon the whole, to move the stern to port (in going ahead, with helm amidships). The conclusions of theory in this matter are confirmed by an interesting experiment in which the rudder was divided into two parts by cutting it horizontally. With the two parts left free to move and the screw turning ahead (the ship being at rest), the upper part took up a position at an inclination of nearly 10° on one side of the keel, while the lower part stood at an equal angle on the other side. In other experiments, where the full rudder was left free to move under the influence of the screw current alone, it took a position at a small but distinct angle with the keel on the side toward which the current from the lower blades tended to deflect it.

If the rudder, instead of being kept amidships, is put over to one side, the sternward velocity of the current will have its effect, as well as the rotary velocity.

With the ship and screw both going ahead, this part of the current will add its effect to the ordinary steering effect of the rudder, and simply produce a greater turning force than would otherwise exist. It may happen, however, that the screw is moving ahead and sending its current aft against the forward side of a hard-over rudder, while the ship is moving astern and developing its ordinary effect upon the after side. This is the case when a ship, while moving astern with some velocity, suddenly puts her helm hard over and throws her engines full speed ahead. This case, which is one of special importance, will be treated at considerable length in a later section.

(b) If the screw is backing, it draws in a current from aft and forces it out forward, where it strikes against the sides of the afterbody with the diagonal velocity given by the rotary motion of the blades. In this case, the " suction " current, coming from aft, will have no effect as long as the rudder is amidships, since its motion is parallel to the keel; but if the helm be put over to either side, this current assumes great importance and may even become the controlling factor in the steering of the ship. So long as the ship is moving astern, this factor acts with the ordinary resistance of the water and simply increases the rudder's turning power. But in the case where the engines are suddenly backed while the ship has headway, this " suction " current opposes and reduces the natural steering power of the rudder, and may altogether overcome it and throw the ship's head to the opposite side from that to which the rudder would throw it under ordinary conditions. This case is the converse of that described under (a) and is one of the most important with which we shall have to deal in the later sections of this chapter.

We have now to consider the effect of that part of the screw current which, in backing, is thrown off from the screw and driven forward against the afterbody of the ship. Since this current partakes of the rotary motion of the screw, it will strike the stern at a considerable angle to the keel line and will produce a pressure tending to force the stern off toward the side to which the blades are moving. It is clear that the upper blades of our right-handed screw will be moving over from starboard to port and sending their current against the upper starboard side of the stern, while the lower ones send theirs against the port side in the neighborhood of the keel. We have thus two forces acting against each other; but a little consideration of the shape of the stern and the position of the screw will make it clear that the upper blades are much more favorably situated than the lower ones, so far as this effect is concerned, and that we may fairly expect their current to prevail over that from the lower ones. Not only are they closer to the body of the stern, but they drive their current against it at a much more effective angle, owing to the fullness of the upper, as compared with the lower, run. We might then expect that the effect of this part of the screw current would be, upon the whole, to force the stern to port; and this is found to be the case in practice.

If the helm be kept amidships, so that the effect of the rudder is eliminated, the stern of a right-handed screw steamer, in backing, works off to port. It does not follow that this is entirely due to the screw current, for we shall find that the factor we are next to consider—the sidewise pressure of the blades—may have much to do with it; but experiments show that the screw current is an important factor in the matter and that its action is as above described.

3. The Sidewise Pressure of the Screw Blades.—As the blades revolve, they exert a force tending to drive the stern off to the side opposite that toward which they are moving. Since the upper and lower blades move toward opposite sides, we have here two forces acting against each other which would exactly balance but for the fact that the lower blades, moving under greater pressure than the upper ones, meet with greater resistance and exert a greater force. The result is that the

pressure of the lower blades preponderates; and in any given case, the stern tends, so far as this element is concerned, to work off to the side from which the lower blades are moving. In going ahead, then, the tendency of the stern is to starboard, whereas in backing, it is to port.

It is found that this factor is not of great practical importance under ordinary circumstances, but that it becomes so whenever, from imperfect immersion or from any other cause, the upper blades " churn " the surface water. It is a fact of every day observation that when a steamer is starting from rest, either going ahead or backing, the screw, even though well immersed, usually " churns " more or less until the ship has gathered way. Under these circumstances, therefore, this factor has maximum effect. Its effect is also important even when the ship has way, if the upper blades are only partially immersed. The fact that it does not count when the ship has headway and when the screw is well immersed is due to the factor which we have next to consider.

4. THE WAKE CURRENT.—This is a current which the ship carries with her as she moves ahead through the water, by reason of the friction between the water and the hull. The body of water involved in it extends to a considerable distance on either side, but attains its maximum volume and velocity immediately under the stern; that is to say, in the vicinity of the screw and the rudder; where it breaks up the water, and, by its forward velocity, materially adds to the pressure on the upper blades of the screw. It is essentially a surface current, and experiments show that it decreases as the depth of water increases and that, at the level of the keel, it is practically imperceptible.

It is difficult to assign any definite value to the velocity of this current, but it has been assumed in certain investigations by Professor Rankine at 10 per cent of the speed of the ship. It enters into our problem only in cases where the ship is moving ahead.

The effect of the wake current upon the rudder is to reduce the steering power. Its effect upon the screw is to increase the resistance to be overcome by the upper blades, and thus to offset the advantage of the lower blades in direct turning effect due to the greater depth in which these blades move.

We proceed now to consider the effect of the elements which have been described, upon the behavior of a steamer under various conditions.

This subject will be treated under the following heads:

1. Ship and Screw going Ahead.
2. Ship and Screw going Astern.
3. Ship going Ahead, Screw Backing.
4. Ship going Astern, Screw going Ahead.

§ II.

SHIP AND SCREW GOING AHEAD.

Here the rudder is the great controlling factor, and the problem of manœuvring under these conditions may be treated practically with very little reference to the effects of the screw. It would not be exact to say that these effects are wholly inappreciable, for there are conditions under which they become clearly apparent; but they are rarely important and it would be almost impossible to lay down satisfactory rules with regard to them. All that need be said of them may be summarized as follows:

If the helm is kept amidships, the screw has a slight tendency to throw the head to port while the ship is gathering way and moving slowly ahead. As the speed increases, this tendency gradually disappears and at medium speeds the screw seems to have no steering effect whatever. Finally, at high speeds, there seems to be with some ships a slight tendency of the head to starboard.

If the helm is put over to either side while the screw is turning but before the ship has gathered way, the discharge current from the screw exerts a powerful steering effect, driving the stern off exactly as if the ship were moving ahead; and this effect continues in a gradually decreasing degree as the ship gathers way and works up to the speed which is properly due to the revolutions of the screw at the time. Thus, if the helm is put to port and the screw started ahead with a number of revolutions corresponding normally to a speed of ten knots, the head will turn at once to starboard, as if the ship were moving. As the ship gathers way, the steering effect of the screw gradually falls off and is replaced by the normal steering effect of the rudder for headway. We may put this differently by saying that the steering effect of screw current is due to the "slip" of the screw.

We proceed to consider the steering of a ship when steaming ahead, as affected by the rudder alone; beginning with the case

Plate No. 89.

Turning Curves for Ships of
Different Lengths and Characteristics.

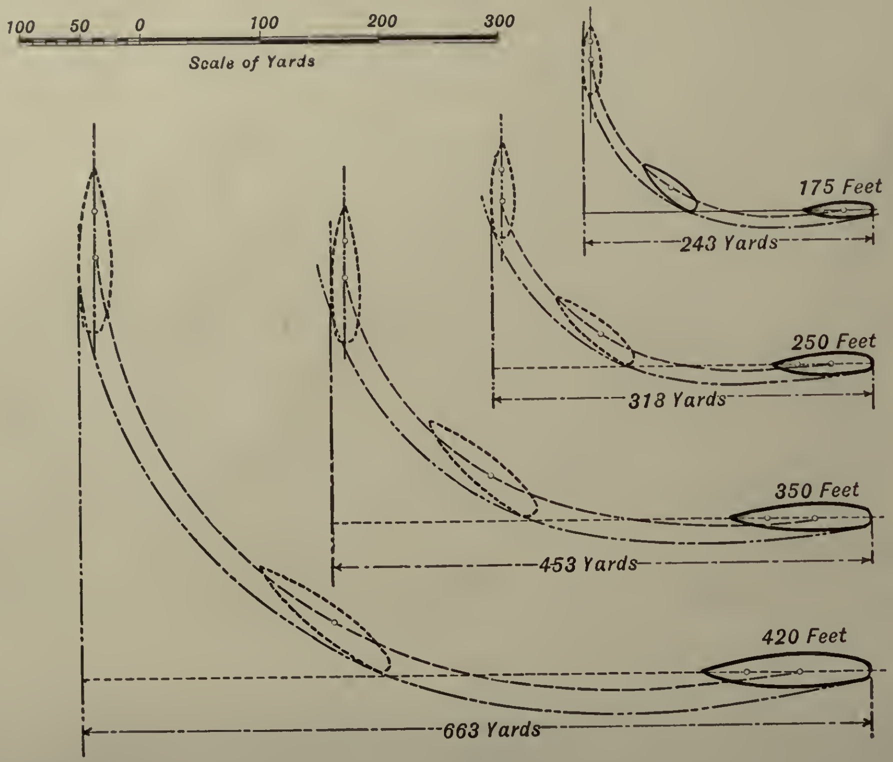

Fig. 1

Turning Curve for Ship of Medium Length
and Average Characteristics (Length 320 Feet.)

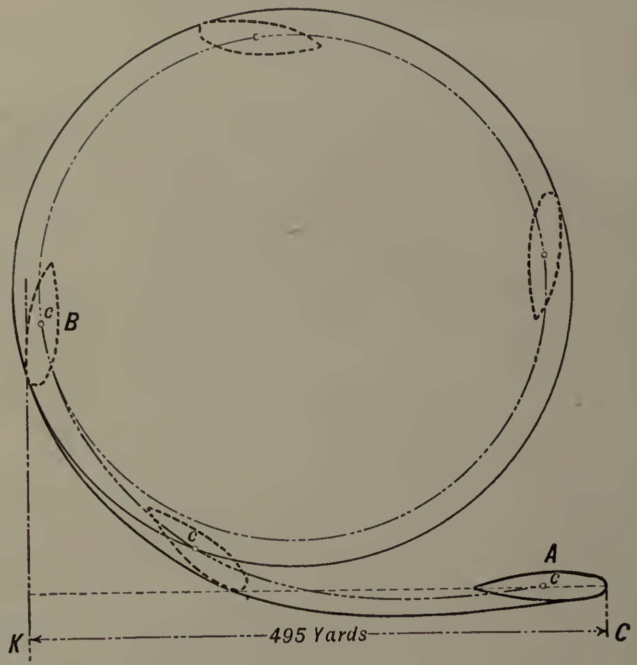

Fig. 2

TURNING CURVES.

in which the ship, while running at fair speed, puts the helm suddenly hard over, without reversing or stopping the engines. This case presents certain points the examination of which will be helpful in dealing with other cases to be taken up later.

In Plate **89** are shown the curves traced out in this way by a number of ships of widely different types. Some of these ships had twin-screws, but it is found that so long as both screws are kept turning ahead, there is no important difference between the curve of a single screw and that of a twin-screw ship.

Observe that not only does a short ship turn in a shorter absolute space, but she turns also in a smaller number of ship's lengths. Thus for a ship 100 feet long, the "advance" will be approximately 3½ lengths (350 feet) while for one 500 feet long it will be more nearly 4½ lengths = 2250 feet.

From these and other curves too numerous to be reproduced here, a curve has been constructed for such an average ship as the one to which we are at present confining our attention. Fig. 2, Plate **89**. It is clear that the differences between this and the individual curves from which it has been derived are very slight and are all differences of degree, not of kind. The following discussion of this curve may therefore be accepted as practically exact for all ordinary types of ships.

It will be noted that, the helm being put hard over as rapidly as possible (position A), the ship begins to turn at once and turns with increasing rapidity up to about the point B, from which point onward she turns uniformly in a path which is practically a circle. As she swings around the circle, her bow points steadily inward while her stern sweeps out a circle considerably larger than that traced by her bow. She does not, that is to say, follow her own keel line, but presents her bow and side to the water through which she moves. To this statement, however, some qualification must be made, since there is one point of the ship which does, at every part of the circle, follow the line along which the keel is pointing at that part. This is called the "Pivoting Point." It is the point about which the ship turns, as viewed by an observer on board. Its position depends upon the speed and the manœuvring power of the ship. When these are exceptionally high, it is well up toward the stem, and it may even be outside and ahead of the ship, on the keel line prolonged.

In our average ship, we may take it about one-quarter the length of the ship from the stem.[1]

An analysis of the curve brings out the following points:

1st. The first effect of putting the helm over is to throw the whole mass of the ship off to leeward, so to speak; that is to say, to the side opposite that toward which it is desired to gain ground.

The stern goes off most; but the whole ship, except the extreme bow, is thrown more or less to this side, and some experiments have seemed to show that even the bow goes off at first. This throw of the stern to leeward is technically the "*kick*."

2nd. The ship ranges ahead nearly along the line of her original course, but slightly to leeward of it, for a distance which may be roughly stated as from two to three ship's lengths, before she commences to gain ground in the desired direction.

> The momentum of the ship along her original course persists for a time and drives her on along this line in spite of the forces which are turning her head away from it.

3rd. The stern does not finally clear the line of the original course until it has covered from two to three lengths measured along that line. In the meantime, the ship's head has changed by more than three points.

4th. If this manœuvre were resorted to for the purpose of avoiding a danger suddenly discovered dead ahead and distant from two to three ships' lengths, it would probably be ineffectual.

5th. The distance covered parallel to the original course from the time of putting the helm down until the ship has turned through eight points, is in this case approximately four lengths. This is called the "*Advance*" and in the figure is represented by the distance C K (Fig. 2, Plate **89**).

All of the above points are brought out in a very striking way in the curve of the Yashima—a ship of altogether exceptional manœuvring power and of high speed (Fig. 1, Plate **90**).

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[1] It is doubtless true, as pointed out by Admiral Colomb and others, that the pivoting point changes its position in the early part of the turn and does not settle down as a fixed point until the ship's path has become a true circle. The variation, however, is not important for our present purpose.

Plate No. 90.

Fig. 1

Turning Circle-Yashima

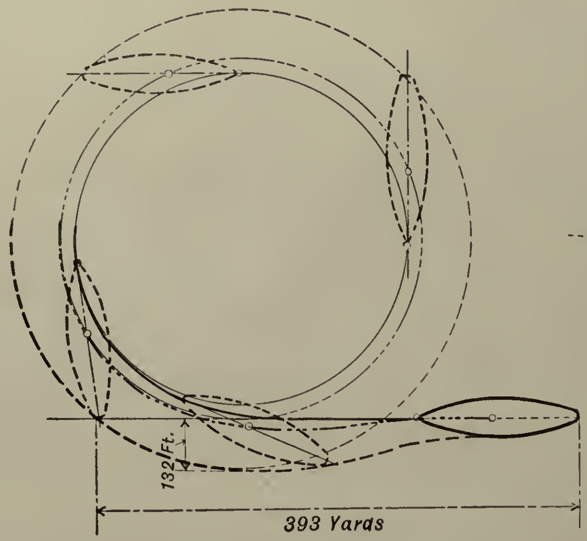
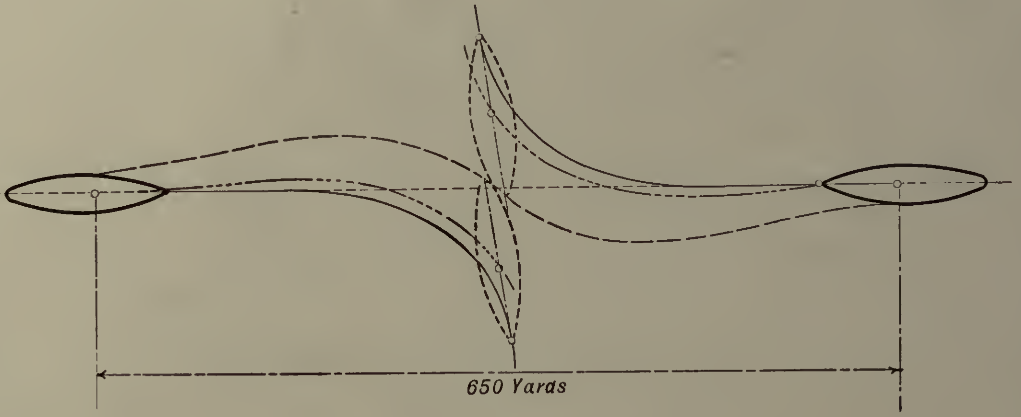
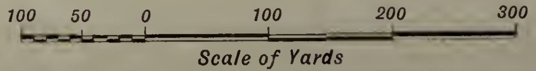


Fig. 2

Two Yashimas meeting





TURNING CURVES OF YASHIMA.

The characteristics which have been noted in the other curves are all present here in an exaggerated form. It will be seen that if two Yashimas, sighting each other dead ahead, should put their helms hard aport while separated by a distance of 650 yards (5 ships' lengths) their sterns would collide (Fig. 2, Plate 90).

The remarkable manœuvring power of the Yashima is due to the fact that her after deadwood is cut away to a very unusual extent. This reduces the resistance of her afterbody to lateral motion, and as a result the stern is thrown off much more rapidly and to a greater distance than would ordinarily be the case. This illustrates very strikingly the fact that it is the stern and not the bow of the ship that moves in turning.

With regard to the speed involved in these curves, this begins to fall off, as might be expected, the moment the helm is put down, the reduction being due to the resistance of the rudder and the sidewise motion of the ship. It continues to fall off until the point is reached where the turning curve becomes uniform and circular, at which point it has fallen off to something like 60 per cent of its original value. From this time on, it remains constant as long as the turn continues with the same helm angle.

It is found that the speed at which a ship is moving when her helm is put over does not greatly affect the space in which she will turn. A ship running at eight knots speed, putting her helm down suddenly, follows very nearly the same track as if she were running at twelve knots. This is a result which would perhaps hardly have been anticipated, but it has been demonstrated by too many experiments to be called in question. As regards the *time* of turning, there is, of course, a great difference in favor of high speed.

It follows that if a ship is attempting to clear a stationary object by putting her helm hard over, it makes little difference with regard to her success whether she slows or continues at full speed, though it will make much difference in the force with which she strikes, if strike she must. If the object to be avoided is another ship under way, there will be an advantage in gaining time by slowing, as this will give an opportunity for both ships to recognize the situation clearly and to act accordingly. It is important to remember, moreover, that *during the time actually occupied in putting the helm over,* a steamer running at high speed will cover a greater distance than if she were running slow.

We do not here deal with the question of reversing the engines. This will be considered in a later section.

We have thus far confined our attention to the effects of a helm put suddenly hard over. This is an exceptional case, but it brings out very clearly the points that are involved in the more common case in which a small angle of helm is used—generally for a short time only—and a small change of course effected. In this case, also, the stern is thrown off, and for some time the body of the ship moves along a line to leeward of the original course. This should always be taken into account. It becomes of great importance when manœuvring in crowded waters, and in all cases where the danger to be avoided is close aboard. The realization that the stern moves and not the bow, will often make all the difference between a close shave and an inevitable disaster.

We have seen that the effect of speed upon the space in which a ship will turn with a given angle of helm is not great. It should, however, be remarked, that a fair speed is essential for the proper handling of any ship. Not only is a ship when moving very slowly through the water at the mercy of the wind and sea and tide, which under such circumstances have an undue effect upon her, but all the varying and conflicting elements that have been described in § I are liable to manifest themselves in unexpected and seemingly erratic ways. It is therefore important always to keep up a reasonable speed; and while this term is hardly susceptible of exact definition, it will probably be agreed that such a ship as we are at present considering—of average size and manœuvring powers—will not handle with certainty at speeds much below four knots.

We shall discuss in another chapter the theory held by many seamen, that it is safer to run at maximum speed through a fog than to slow down.

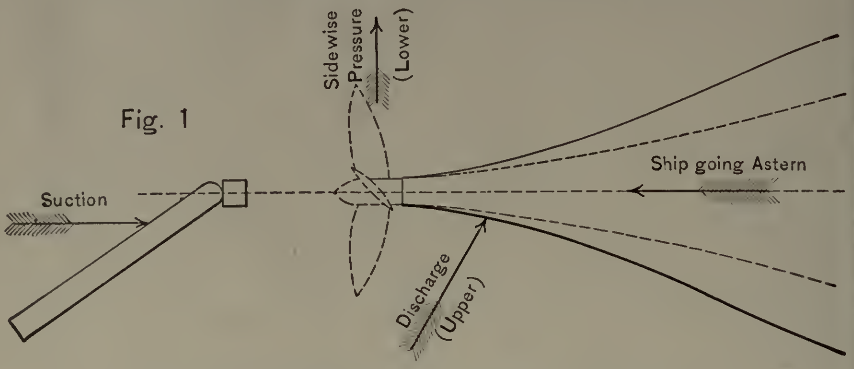
Although it is found, as has been explained, that when a ship is going ahead, the rudder so far outweighs all other elements involved in the steering that these other elements may in general be neglected, it is nevertheless true that hardly any ship turns with exactly the same readiness to port and to starboard; and it appears from experiments to determine the tactical diameter of men-of-war that the circle made with port helm may differ from that with starboard helm, by as much as ten per cent.

Although we are dealing at present with the *turning* of ships, it may be well to add a word with regard to the power of *stopping*.

Plate No. 91.

Ship and Screw going Astern. Ship beginning to back.

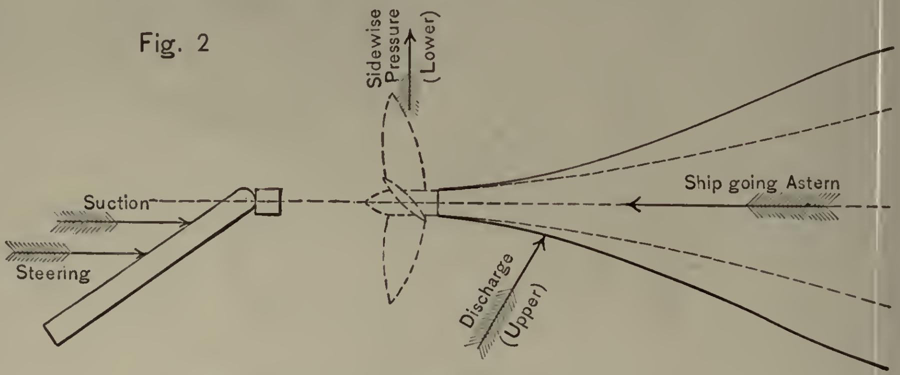
Fig. 1



Stern usually goes to Port, Head to Starboard.

Ship and Screw going Astern. Ship Moving Astern.

Fig. 2



Stern may go to Starboard, Head to Port.

Ship and Screw going Astern. Ship Moving Astern.

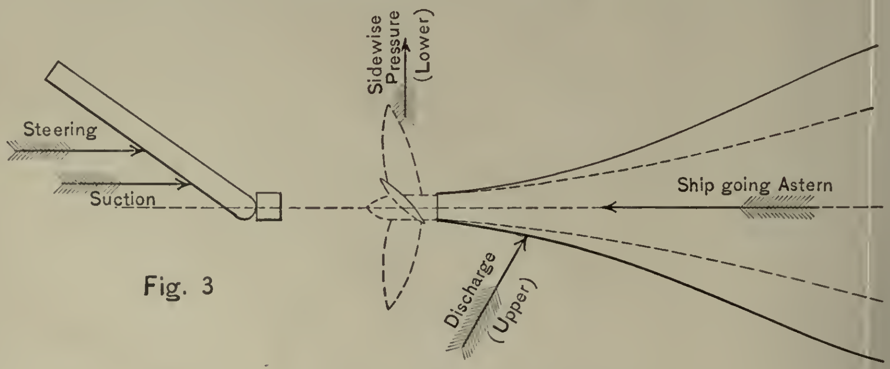


Fig. 3

Stern goes rapidly to Port, Head to Starboard.

EFFECTS OF SCREW UPON STEERING.

It is found that a ship steaming ahead with the helm amidships, and suddenly reversing her engines without moving the helm, will stop in from three to five times her own length; and that this distance is practically independent of the size and speed of the ship.

This supposes the same power used in backing as in going ahead. If there is a reserve of power available for backing, a ship should be stopped in twice her length.

The space in which a ship can be stopped, as compared with that in which she can be turned, becomes important when danger is suddenly discovered ahead and on both bows; as, for example, when a ship finds herself heading for a coast or a line of reefs, and dangerously close. We have seen that she may, by putting her helm hard over, turn through eight points with an "*advance*" in the direction of the original course, of about four lengths. This would seem to show that it is at least as safe to try to clear such a danger by means of the helm, as by stopping the ship.

This was the conclusion of the Committee of the British Association (see Report British Association 1878, page 422).

It will be shown later that probably the safest course of all is to combine both methods, putting the helm hard over (preferably to port), and when the head has begun to swing decidedly, reversing full speed and immediately *afterward* shifting the helm.

The time and space in which a ship may be brought to rest when moving at a given speed are matters of great practical importance. The time may be determined by the very simple experiment of reversing the engines and noting the number of seconds required to come to rest. Observations upon the space are not so easily made, but experience shows that the space may be determined with considerable accuracy from the observed time, by the simple formula:

$$D = 7/10\ ST.$$

Where D = Distance in feet required to stop.
S = Speed in knots and tenths.
T = Time in seconds (observed).

See "General Information Series No. IX," issued by Office of Naval Intelligence, U. S. Navy Department.

§ III.

SHIP AND SCREW GOING ASTERN.

(Plate **91.**)

This case is more complicated than the preceding one, for the reason that the effects of the screw, which in going ahead are so far overpowered by those of the rudder that they may usually be neglected, become, in backing, quite as important as those of the rudder, and in many cases much more important.

The forces involved in the steering of a steamer in backing are:

1. The Sidewise Pressure of the Blades, driving the stern to *port*.

2. The "Discharge" current, thrown forward and inward from the screw, against the sides of the run, and tending also to drive the stern to *port*.

3. The "Suction" current, drawn in from aft against the after side of the rudder, and acting to throw the stern to starboard or to port according to the way the helm is put. This factor does not enter into the problem with the helm amidships.

4. The ordinary steering effect of the rudder, tending to throw the stern toward the side opposite that to which the helm is put. This factor does not enter into the problem with the helm amidships.

3 and **4** above are closely related and act together, but **4** is dependent upon the motion of the ship through the water, while **3** is independent of this motion and connected only with the action of the screw. For this reason, we must distinguish between the case in which the ship is just starting astern from rest, and that in which she is moving astern with considerable velocity. In the first case we may ignore **4**, while in the other we must consider it. In both cases, we shall find an inclination for the stern to back to port, due to the fact that **1** and **2** always act in that direction, while **3** and **4** act with or against them according as the helm is put to starboard or to port.

(a) If the ship is just beginning to back, **4** may be neglected, and **3** will tend to drive the stern to the side opposite that to which the helm is put. If, then, the helm is a-starboard, **3** will act with **1** and **2**, and the tendency to port will be very marked. If the helm is aport, **3** will oppose **1** and **2**, but will not usually overcome them; and the tendency of the stern to port though very much reduced, will still exist. In other words, a steamer just beginning to back from rest will in general throw her stern to port even against a hard-over port helm.

(b) As the ship gathers speed astern, 4, the steering effect of the rudder, becomes of greater and greater importance. It always acts with the suction current (3) upon the after side of the rudder; and if the helm is put to port, these two forces (3 and 4) may ultimately overcome 1 and 2 and give the stern a slight tendency to starboard. If, on the other hand, the helm is put to starboard, all four of the forces involved act together and throw the stern rapidly to port.

It results from the above, that when a ship is beginning to back but has not yet gathered decided stern-board, it is difficult, if not impossible, to prevent her stern from working off to port; and that after she has gathered considerable speed astern, she will still have a decided inclination to back to port, but may usually be made to back to starboard by hard-over port helm.

If it is desired to back as nearly straight as possible, the helm must be put hard aport.

The effect of a breeze is not great upon a vessel moving slowly astern, but becomes important as the speed increases; so much so that, with a moderate breeze, a vessel going astern at a speed of three knots or more will back up into the wind in spite of all that can be done to prevent it. It follows that, in spite of the tendency to port which has been insisted upon above, a ship may be backed to starboard, if the breeze is from that side, provided that the circumstances admit of going astern for some time and at fair speed. It follows, also, that if it is desired to back to port while the breeze is from the starboard side, the more slowly we go astern the better, and if the breeze is fresh, it will probably be impossible to avoid backing into it.

Generally speaking, a ship is backed only when working alongside a dock or into a slip, or when manœuvring in crowded waters; conditions which do not admit of backing for a long time or at any considerable speed; and under these circumstances, it is desirable to plan all manœuvres in such a way as shall involve the throwing of the stern to port in backing.

§ IV.

SHIP GOING AHEAD. SCREW BACKING.

This is in some respects the most important case with which we have to deal, for the reason that it is the one most frequently connected with the emergency of danger suddenly discovered and close aboard. The cause of many collisions can be traced to a widespread ignorance of the rules which govern the steering when the engines are suddenly reversed while the ship is going ahead. Yet these rules are simple and have been stated many times.

It is assumed, naturally enough, by those who have not studied the many practical experiments which have been made in connection with this matter, that so long as the ship has headway she will continue to obey her helm in the usual way, even though the screw is backing and gradually reducing her speed.

This is so far from being the case, that in many instances exactly the opposite occurs; the matter being complicated, from the instant the engines are reversed, by the "screw current" which has been described in § I as being drawn in against the after side of the rudder and driven forward against the afterbody of the ship.

The forces involved in the steering under these conditions are the following:

1. The direct steering effect of the rudder, tending, as in all cases of headway, to throw the stern toward the side to which the helm is put.
2. The "Suction" current, drawn in from aft by the screw, against the after side of the rudder, and forcing the stern toward the side opposite that to which the helm is put.
3. The "Discharge" current driven forward and inward against the stern, forcing the stern to port, without reference to the helm.
4. The Sidewise Pressure of the blades, also forcing the stern to port, without reference to the helm.

(Plate **92**.)

We have here a number of conflicting elements, the final result of whose action it would be useless to attempt to predict from theoretical considerations. Since, however, there are two of them which always act to throw the head to starboard, we may be sure, at least, that the ship will turn much more readily to that side than to the other.

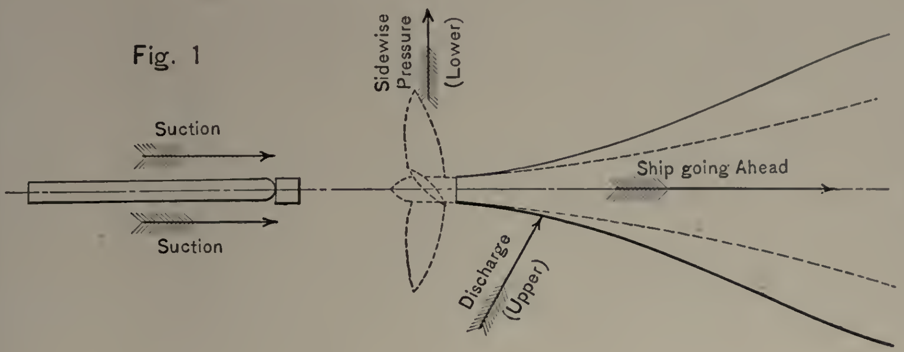
We proceed now to consider the matter from the point of view of practice, and we are fortunate in having the result of several very complete series of experiments, from which to draw our conclusions.

In 1875, Professor Osborne Reynolds communicated to the British Association for the Advancement of Science, the results of certain experiments made with models for the purpose of determining the effect of the screw upon the steering of steamers; and for several years after this time, he was engaged, as Secretary of a committee appointed by the Association, in experiments and

Plate No. 92.

Ship going Ahead. Screw Backing.

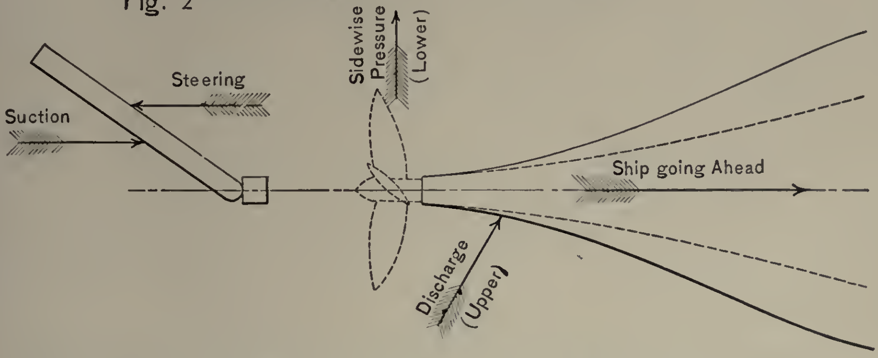
Fig. 1



Head goes to Starboard.

Ship going Ahead. Screw Backing.

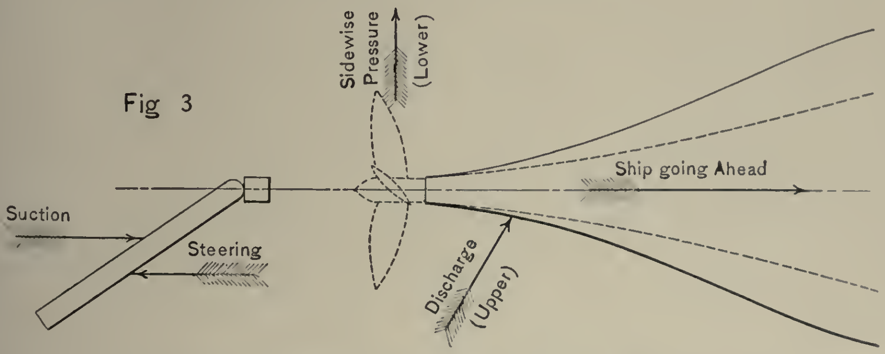
Fig. 2



Head goes to Starboard decidedly, May go slightly to Port at first.

Ship going Ahead. Screw Backing.

Fig 3



Forces nearly balance. Head will usually go a little to Port.

EFFECTS OF SCREW UPON STEERING.

investigations upon the same subject. The reports of this Committee are to be found in the Proceedings of the Association for 1876, 1877, and 1878.

Since these reports were made, much additional evidence has become available, and it is now possible to lay down fairly definite laws with regard to the behavior of ships under the circumstances we are now considering, although it must never be forgotten that exceptional conditions, especially of weather and of the draft and trim of a ship, may modify all such laws in ways which can only be foreseen by an officer thoroughly familiar with the peculiarities of his ship and her temporary condition as regards draft and trim.

The following rules will usually be found to hold for our right-handed screw steamer, of average characteristics, when the engines are suddenly reversed from full speed ahead to full speed astern.

(a) **The helm kept amidships.**

The head will fall off to the starboard, and the ship will gain ground to the right before losing her way. The stern will, in the beginning, go off slightly to the left, and the mass of the ship will range along the line of the original course or a little to the left of it (Fig. 1, Plate **92**).

(b) **The helm put hard a-starboard at the same instant that the engines are reversed.**

The head will usually go to port at first, but neither very rapidly nor very far; it will then begin to swing to starboard and will fall off more or less to that side. The ship will gain ground to the right of her original course, before losing way (Fig. 2, Plate **92**).

(c) **The helm put hard aport at the same instant that the engines are reversed.**

The head will at first go to starboard and may in some cases persist in swinging to that side, though not nearly so fast or so far as in (b). In a majority of cases, after swinging somewhat to starboard, it will stop and swing slowly back to port, and the ship will come to rest with her head from one to two points to port of her original course. She will not gain ground materially to either side (Fig. 3, Plate **92**).

The more slowly the ship is moving ahead, and the faster the screw is backing, the more confidently may we expect her to behave as above described. The rules that have been given, and indeed the whole preceding analysis, suppose the screw to be backed at full speed from the first instant, as it should be in all cases where certainty of manœuvring is important.

If the ship is running slowly, but with a reserve of power immediately available for backing at high speed (as should always be the case in a fog), the rules which have been laid down may be relied upon with especial confidence, since they are based upon the power of the backing screw to overcome the steering effect of the rudder due to the speed of the ship. So in the other important case of turning or manœuvring in a limited space or working alongside a dock, where the power available for backing will always be great in proportion to the speed of the ship.

If, on the other hand, while the ship is moving ahead at high speed, the engines should be reversed with only half power, the ship would unquestionably obey her helm for headway; a port helm throwing her head to starboard in spite of the slowly backing screw.

The case with which this section has chiefly dealt—that in which the screw is backed with power equal to or greater than that corresponding to the speed of the ship—is the ordinary case of practical seamanship, covering both the situation where the screw is backed for manœuvring a ship in harbor, and that where it is suddenly reversed when going ahead at some speed, to avoid danger suddenly discovered.

As the whole question herein dealt with is one of opposition between the steering effect of the rudder due to the speed of the ship and the steering effect due to the screw current, it will be easily understood that there may be cases in which the balance of these forces will be different from that which is here described for "average" conditions, and in which, accordingly, the behavior of the ship will differ from that described. But while we may admit that in some cases a ship backing her screw with full power will still obey her helm for headway, it must be insisted none the less strongly that the screw current will have a powerful effect in the direction herein described and that if the ship obeys her helm for headway it will be with greatly lessened effect.

The *time* of putting over the helm exercises an important influence upon the behavior of the ship. If it is put over before reversing the engines, the ship's head will of course commence to swing in direct obedience to it (for headway), and the screw cannot be expected to overcome this and to produce the same effect as if it were reversed simultaneously with the putting over of the helm.

If the ship has actually begun to swing in obedience to a hard-over helm before the screw is reversed, she will in most cases continue to swing the same way in spite of the screw, although much less rapidly than if the screw were not reversed.

If, on the other hand, the engines are reversed before the helm is put over, then the rules laid down above are emphasized; and it should be noted that the helm can be put over more rapidly after the screw is reversed than before. This may be a very important point with ships steering by hand-power.

It is probable that some ships will, for a very short time, continue to obey the helm as for headway, even though the helm is put over at the same time that the screw is reversed; but as they will shortly begin to act in accordance with the above rules, there are very few cases in which we can run into any danger by considering the rules to hold.

We may usually remove all question with regard to the movement of the ship by putting the helm to one side before reversing the screw, *thus getting a swing on the ship in the desired direction*, then reversing the screw, and following this up by reversing the helm. Suppose, for example, we wish to throw the head to starboard. We stop the engines and put the helm hard aport, and when the head has begun to swing to starboard, reverse the engines and immediately shift the helm to hard a-starboard. If we wish to turn to port, we stop, put the helm a-starboard, and wait a little longer than in the preceding case—(since the head does not turn to port as easily as to starboard with engines backing)—then throw the engines to full speed astern and follow this by putting the helm hard aport. By this means we shall remove all doubt about casting to port, although the turn to that side will be made slowly, even under these conditions.

The rules laid down above are summarized in the statement that, in general, a ship tends to obey her helm with reference to the way the *screw* is moving, not with reference to the way the *ship* is moving.

§ V.

SHIP GOING ASTERN. SCREW GOING AHEAD.

This case closely resembles the preceding one and is subject to the same general law; viz., the ship obeys her helm with reference to the motion of the screw, not the motion of the ship.

The forces involved in the steering are:

1. The direct Steering effect of the Rudder due to sternboard, acting to starboard or to port according to the way the helm is put.

2. The Sidewise Pressure of the Blades, acting to drive the stern to starboard.

3. The Discharge Current thrown off by the screw, and consisting of two components; (a) acting directly astern, and (b) acting inward against the starboard side of the rudder post and tending always to force the stern to port.

If the helm is amidships, 1 and 3 (a) are eliminated from the problem, and only 2 and 3 (b) are to be considered. These two oppose each other, and it is impossible to foresee, in any given case, which one will prevail (Fig. 1, Plate **93**).

If the helm is aport we shall have 1 and 2 forcing the stern to starboard, and opposed by both components of 3 (Fig. 2, Plate **93**).

It is found in practice that, under these conditions, the effect of 3 greatly exceeds that of the other factors, and that the stern goes off decidedly to port.

If the helm is a-starboard, we have 2 acting as before to force the stern to starboard, and assisted now by 3 (a), while 3 (b) acts with 1, to force it to port. In practice, the forces acting to starboard commonly prevail, and the stern goes to that side (Fig. 3, Plate **93**).

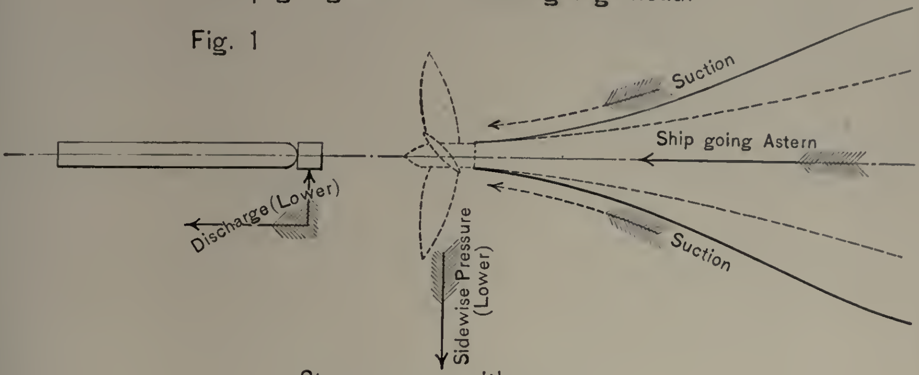
A comparison of the figures illustrating this case will show that 1 and 3 (a) are in every instance opposed to each other, as are also 2 and 3 (b). Of these forces, 1 and 3 (a) are by far the most important, and the course of the ship is usually determined by their relative values.

It is found in practice that, as a general rule, 3 (a) (the screw current acting against the forward side of the rudder), overpowers 1 (the resistance of the water on the after side), and, as already stated, the ship obeys her helm with reference to the motion of the screw, not of the ship. This assumes that the sternward velocity of the ship is not great, and that the screw is turning ahead full speed—the usual conditions when manœuvring in this way. If the opposite conditions exist, that is to say, if the ship is moving rapidly astern and the engines are turning slowly ahead,

Plate No. 93.

Ship going Astern. Screw going Ahead.

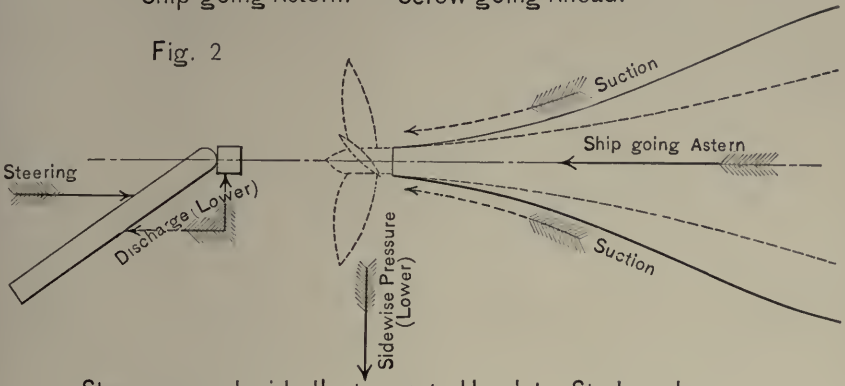
Fig. 1



Stern may go either way.

Ship going Astern. Screw going Ahead.

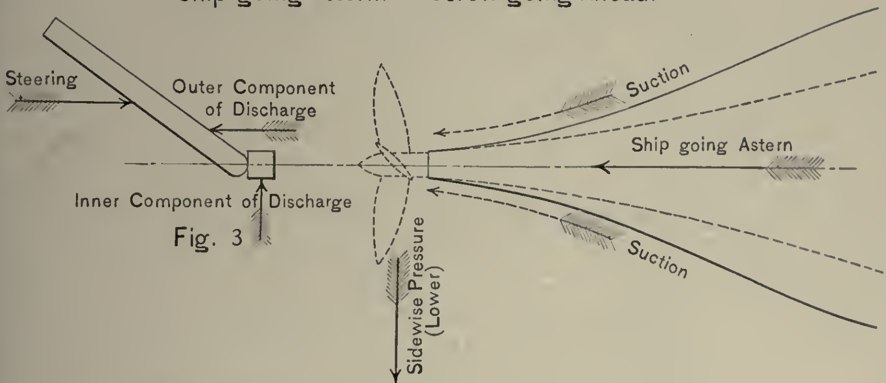
Fig. 2



Stern goes decidedly to port, Head to Starboard:

Ship going Astern. Screw going Ahead.

Fig. 3


Steering
Outer Component of Discharge
Suction
Ship going Astern
Inner Component of Discharge
Sidewise Pressure (Lower)
Suction

Stern usually goes to Starboard, Head to Port.

EFFECTS OF SCREW UPON STEERING

it may be found that the natural steering power of the rudder will overcome the feeble screw current, and that the ship will obey her helm as in ordinary cases of sternboard.

The resemblance between the case described in the present section and that dealt with in § IV is very close, but one important difference should be noted. The *discharge* current driven aft when the screw goes ahead is more directly localized in its effect upon the rudder than is the *suction* current which is drawn in from aft by the screw when backing. While the suction current comes in a general way from abaft the screw and the rudder, only a part of it moves directly in line of the shaft, the remainder being sucked in from all sides more or less radially. The discharge current, on the other hand, although partaking to a certain extent of the radial motion of the blades, is localized upon the rudder as a distinct and powerful stream.

It results from this that the turning effect of the screw when the ship is going astern and the screw going ahead, is usually more pronounced than the corresponding effect when the ship is going ahead and the screw going astern.

§ VI.

TO TURN IN A LIMITED SPACE.

For reasons which have been already explained, it is difficult to turn a right-handed single screw steamer to port under any circumstances, where backing is necessary, and almost impossible to do so in a limited space. Under these conditions, therefore, the turn should, if possible, always be made to starboard, even if a little preliminary manœuvring is needed to place the ship in a position permitting this.

The ship being at rest, proceed as follows:

1st. Put the helm hard aport and go ahead with the engines. The stern will swing off to port immediately. As she starts ahead, she will turn more and more rapidly. Allow her to gather as much way as is safe, and to forge ahead as far as space permits; then—

2nd. Reverse the engines full speed, and at the same time shift the helm to hard a-starboard. The suction current against the after side of the rudder, assisted by the discharge current acting against the run, and by the pressure of the blades, will keep the stern swinging to port; and as she gathers sternboard (if allowed to do so), the direct steering action of the rudder will help in the same direction.

Let her gather such sternboard as is safe, and back as far as space permits; then—

3rd. Go full speed ahead and shift the helm to hard aport. It is at this point that the most pronounced turning effect is to be anticipated. The whole power of the screw is producing a screw current and driving this current against the hard-over rudder.

4th. If necessary, continue going ahead and backing as above (Plate **94**).

If more convenient to make a sternboard first, begin by backing with helm a-starboard.

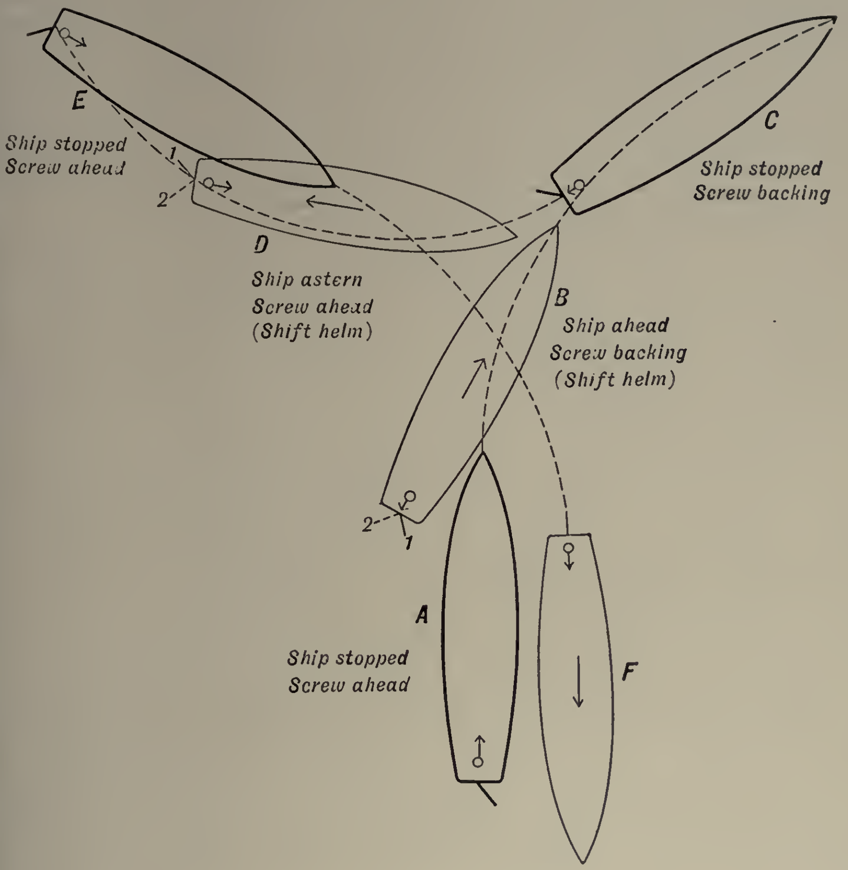
If there is a fresh breeze on the *starboard* hand, avoid gathering any considerable sternboard, or she will back into the wind in spite of all that can be done. If the breeze is on the *port* hand, there will be an advantage in going astern as fast and as far as the surrounding dangers permit.

If the space, although limited, is sufficient to admit of going ahead and astern for a considerable distance and at fair speed, it will not be so difficult to turn to port, although the turn to starboard will always be more easily and rapidly made. Having decided to turn to port under these circumstances, stand well over to the right-hand side of the channel, and go ahead with hard-over starboard helm. Having got good way on her, stop the engines and let her run. So long as she holds her headway, she will turn without difficulty.

Having run as far over as is safe, back the engines at full speed and put the helm aport. As she is starting to back from rest, or nearly so, she will probably throw her stern the wrong way. Continue backing hard in spite of this, and as she gathers speed astern the port helm will probably stop her turning the wrong way, and, if it does not turn her the right way, may at least hold her straight until you can afford to go ahead again. Then start the engines at full speed, put the helm a-starboard, and, as before, run as far as space permits. If necessary, back again, and repeat the tactics as above.

If there is any wind, it should be possible to gain some advantage here by the use of either jib or spanker; in fact, these sails can be used to advantage in nearly all cases of turning in a limited space. The spanker is especially useful as opposing the

Plate No. 94.



TURNING A STEAMER IN A LIMITED SPACE.
(SINGLE, RIGHT HANDED SCREW.)

tendency to back into the wind, in cases where this tendency is unfavorable for the manœuvre to be performed.

If the tide is running out strong and setting you down toward danger, you should, in the early part of the turn, while heading more or less up stream, manage to gain ground against the tide while going ahead; and from the time when you have turned athwart and are beginning to throw the stern up stream, you should take on more sternboard (through the water) than you otherwise would, to hold her up against the current.

A vessel drifting in a current and making no way through the water will usually fall athwart and end by drifting broadside on. This may be a serious danger. In going through Hell Gate, for example, a steamer should never be allowed to lose headway, as she will be beyond control if she gets athwart. On the other hand there are cases in which, with a little space for working ahead and astern, this tendency might be utilized to make a turn which, without it, would be impossible.

It often happens, where a current runs rapidly through a more or less narrow channel, that there is a perfectly marked eddy along the shore running in the opposite direction. This is the case in the East River, where, from the old Brooklyn Bridge to Corlear's Hook, an eddy current of considerable width runs up along the face of the New York docks while the ebb tide is running out with full force in mid-stream. A steamer coming down stream and having to turn to make a landing may run well over toward the Brooklyn side, then turn across with port helm, ranging over and putting her bow in the eddy. In this way, she will turn with great ease. A similar phenomenon exists in the Mississippi at New Orleans, and ships may be turned there in the same way.

It is always worth while to post one's self upon such local peculiarities when likely to have occasion to deal with them.

§ VII.

TWIN SCREWS.

Twin screws have been used for many years, but did not come into general use, either for men-of-war or for merchant steamers, until about 1870, since which date they have been steadily growing in favor. Their advantages are to a great extent connected with the smaller size of screws required for a given power—this reduction in size over that of a single screw permitting large power to be utilized on a small draft, and preventing the racing of the screw as the ship pitches in a seaway. Moreover, the division of power between two screws and two sets of engines permits the use of smaller parts in the machinery, and especially in the shafts. This reduces the danger of flaws and of breaking in these parts, and minimizes the disastrous consequences if such breakage occurs; since a twin-screw ship with one shaft broken or one engine disabled is still perfectly under control and loses only a moderate percentage of her speed.

On the other hand, there is a certain weakness, which becomes important in a modern steamship with a fine run, in the great length of shafting, which, with twin screws, must project outside the ship, supported by struts from the hull. There is also, no doubt, some danger of damage to the screws, which would not exist in a single screw, in entering and leaving docks.

The point in connection with twin screws with which seamanship is principally concerned, is the remarkable gain in manœuvring power which results from their use. It is clear that this must be very great in almost any case, though it will differ widely with different ships; being dependent, broadly speaking, upon the distance between the shafts at the center of gravity relatively to the length of the ship, and upon the angle at which the shafts are placed with each other.

In a ship of small beam as compared with her length, the shafts necessarily approach each other at a rather sharp angle; whereas with plenty of beam they can be kept nearly parallel and separated by a distance which gives a good turning moment.

There is a further important gain in the certainty of manœuvring, due to the more or less complete elimination from the problem of the rather baffling steering effects of a single screw. We must still take account to some extent of the current which is driven aft by each screw in going ahead, and drawn from aft in backing; but the axes of these currents will be well clear of the keel-line and will not materially affect the steering unless the helm is hard over, or nearly so. In the case in which the ship is moving rapidly in one direction and the engines are suddenly thrown the other way, these currents will greatly reduce the steering power of the rudder, but will not *reverse* it, as in the case of a single screw ship. Similarly, in turning with one screw going ahead and the other backing (the ship having headway) the suction current from the backing screw reduces the steering power of the rudder but does not entirely overcome it.

The steering effect due to the sidewise pressure of the blades, which, as we have seen, is often a very important factor in the handling of a single screw ship, disappears with twin screws when both screws are going ahead or backing together. In other cases, it has a theoretical existence, but counts for little or nothing, because the screws are small and thoroughly immersed.

As a twin-screw ship always has one screw right-handed and the other left-handed, the right-handed screw being (usually) placed to starboard and the left-handed one to port, it is possible to throw the stern either way in *backing*, by using one screw only. Thus if it is desired to throw the stern to port we may do this by backing on the starboard (right-handed) screw only, the other one being stopped.

We proceed to consider the turning of twin-screw ships under various conditions:

We shall deal with the following cases:

1. Going Ahead.
2. Backing.
3. One screw going Ahead, the other Backing.
4. Ship going Ahead, both screws Backing.
5. Ship going Astern, both screws going Ahead.

1. Going Ahead.—So long as both screws are making the same speed, the ship should steer with helm amidships, unless affected by wind or sea.

If one screw is stopped, there should be no difficulty in steering a straight course with a moderate amount of helm.

If the steering gear is disabled, there should be no difficulty in making a reasonably good course, steering by the screws, unless the sea is heavy; but this supposes good and rapid communication between the bridge and the engines. In a seaway, there may be some difficulty about steering in this way, but not enough to prevent a ship from proceeding with perfect safety as long as she has sea-room; but we must, of course, recognize the fact that even under the most favorable conditions the screw can never give the sensitiveness of control that comes from a rudder governed by steam power. Experience shows that it is best to keep one engine turning over at a constant rate, somewhat less than the maximum available, and to steer the ship by varying the number of revolutions of the other screw.

If the helm be put hard over when going ahead at full speed, the result will be practically the same as in the case of a single screw. In fact, as already stated, the curves of Plate 89 have in some cases been derived from experiments upon twin-screw ships; and the discussions of these curves already given are entirely applicable to the case we are now considering. We have to recognize the same sweep of the stern to leeward, the same ranging ahead, along, and even to leeward of, the original course, before beginning to gain ground in the desired direction, and the same loss of speed while turning.

It is found that the revolutions of the inner screw are somewhat reduced in turning, the change amounting to perhaps 10 per cent.

From causes which cannot be clearly defined, and which are probably different with different ships, it usually happens that a twin-screw ship turns somewhat more readily to one side than to the other; but the difference is less than with single screws, and is of practical importance only in the case where a full turn is to be made—as in the tactical manœuvring of men-of-war.

2. Backing.—A twin-screw ship, starting from rest with both screws backing, should be entirely under the control of the rudder, though she will steer with much less ease and sensitiveness than when going ahead. If necessary, the rudder may be assisted by a variation in the speed of one or other of the two screws.

3. One Screw going Ahead, the other Backing.—(a) If the ship is just starting from rest, with helm amidships, she will turn rapidly to the side of the backing screw.

If the screws revolve at equal speed, the one going ahead will gain slightly upon the other, since less power is required to drive a ship ahead than to drive her astern, and the ship will turn in a circle of small radius, but not on her heel.

If it is desired to turn her as nearly as possible on her heel, the screw going ahead should be kept at somewhat lower speed than the other, the exact relation between the two being determined experimentally for each ship.

The time of turning under these conditions is considerably greater than where both screws are kept going ahead and the helm put hard over, although the space required is much less.

Many ships will not turn *from rest* by going ahead on one screw and backing on the other. With such a ship, it is necessary to gather a little way and commence turning by the helm before backing the inner screw.

In the special case where the ship is to be turned without gathering headway, *the helm should be kept amidships.* To make this clear, let it be assumed that the turn is to be made to starboard. The starboard screw will be backing and the port screw going ahead. To starboard of the rudder, then, we shall have a suction current moving forward, and, to port, a discharge current moving aft. If, now, we put the helm hard a-port (rudder to starboard), the suction current will strike against the after side and tend to throw the head to port; while if we put the helm to starboard (rudder to port), the discharge current will act against the forward side and will also tend to throw the head to port.

(b) If the ship is moving ahead at fair speed when one screw is backed for the purpose of turning, the helm should be put hard over as if the engines were both continued ahead. Wishing to turn to starboard, we put the helm hard aport, and reverse the starboard screw.

In this case, the suction current of the backing screw, acting upon the after side of the rudder, will oppose the turning, but not sufficiently to deprive the helm of all steering power, as it often does in the case of a single screw. There are several reasons for the difference. In the first place, only half the power of the ship is involved in the backing, whereas with a single screw, the whole power is involved. Again, the suction current in the present case is at some distance to one side, and affects only the outer part of the hard-over rudder; and, finally, the headway is prolonged by the other screw, and this tends to continue the normal action of the rudder.

In turning, then, with considerable headway, and wishing to get the maximum effect, the helm should be used as in ordinary turning, and the inner screw reversed.

As regards the track of the ship in turning under these conditions, we have seen that the curve of a twin-screw ship with both screws going ahead and helm hard over, does not differ materially from that of a single-screw ship; but it would be natural to suppose that the case must be greatly changed when the inner screw is reversed to help the helm. There is, in fact, a considerable difference, but it is far less than is commonly supposed; at least in the first brief interval after the turn begins; in the interval, that is to say, during which the emergency for which the action is taken must work itself out. The complete turning circles will be widely different, but the track of the vessel for some time will be but little modified. The stern will, as in all other cases, go off to leeward, and the ship will gain nothing to the side toward which her head is thrown, until she has covered from two to three lengths along her old track. She will, however, gradually lose her speed, and will throw her head around rather more sharply, with the result that, by the time she does begin to move away from her old line of advance, she will do so at a considerably greater angle than if her helm were merely put over without reversing the inner screw.

4. Ship going Ahead, both Screws Backing.—In this case, if the helm is kept amidships, the ship may be stopped in from three to five lengths.

If the helm is put hard over to either side, we have a case resembling that in which the screw of a single-screw steamer is suddenly reversed; but with some points of difference. In the present case, we shall have a suction current on each side drawn forward by the screw of that side. Whichever way the rudder is put, its direct steering action for headway will be opposed by the suction current of that side alone; that is to say, by only half the power of the total suction. Moreover, this current is so far to one side that its effect will be confined to a small part of the area of the rudder.

Thus the twin screws, in backing, will have much less tendency than a single screw, to reverse the ordinary steering effect of the rudder; and it is found that so long as the headway continues, the ship steers normally (for headway), but turns less rapidly under the influence of the helm than if the screws were going ahead; in other words, the screws in this case reduce, but do not reverse, the normal effect of the rudder.

There is an important gain in the rapidity of turning if the helm is put hard over before the screws are reversed, thus starting the head to swinging in the right direction.

5. Ship going Astern, both Screws going Ahead.—In this case, the ship will obey her helm for sternboard, although the power of the rudder will be materially reduced by the discharge current of the screws.

If necessary, the rudder may be helped, and the ship manœuvred with ease and certainty, by varying the speed of the screws.

§ VIII.

ADDITIONAL NOTES UPON STEERING.

Effect of Wind.

If a steamer is lying in a smooth sea, with her engines stopped and with the wind abeam, she will gradually fall off and bring the wind abaft the beam; this for the reason that the draft is usually less forward than aft, so that the bow has less hold on the water than the stern; that, usually, the bow is higher than the stern and so presents a greater surface to the wind; and that, above all, the screw acts as a drag holding the stern up to the wind.

In going ahead, the wind has no important effect. In backing, there is a marked tendency for the stern to back up into the wind. This tendency increases with the force of the wind and the speed of the ship, and differs greatly with different ships. Some ships cannot be backed at all, even in a light breeze, without throwing their sterns up to it, even though all other forces are acting to turn them the other way.

It will be clear from the above that advantage may be taken of the wind in manœuvring, and that its effect will be felt much more decidedly in backing than in going ahead. We shall have the maximum of favorable conditions for turning, when the wind is fresh on the port hand. Under these conditions, everything favors turning to starboard; and it will be difficult, if not impossible, to turn to port.

The problem of handling a ship becomes one of especial difficulty when she is flying light. In this condition, she has less hold on the water and exposes more surface to the wind. Moreover, the effective rudder area is reduced, and the steering effect of the screw, due to incomplete immersion, is very greatly increased. Thus everything acts to minimize the control of the ship by the rudder. Under these conditions, a steamer may steer fairly well so long as she is in the open sea and under full speed, but she will handle very badly in a harbor, where she has no opportunity to get up speed; and if the breeze is fresh she will be nearly or quite unmanageable. The effect of the screw is to throw her stern off to the side from which the lower blades are moving; so that the bow falls off to port in going ahead, and to starboard in backing. If the wind and screw act together in any given case, the rudder will be practically useless if acting against them; if they oppose each other, it may have some power to control the ship, but the power will, at best, be far below what it is in ordinary conditions of trim.

It can hardly be necessary to state that the ship when flying light will drift bodily to leeward much more rapidly than under ordinary conditions; and that the tide is of relatively greater importance than usual, because of the comparative helplessness of the ship.

Effect of Sea.

A ship lying at rest in a seaway will gradually fall off into the trough of it, and some effort will be required to hold her up. If going ahead, she will tend to keep in the trough, and lee helm will be needed to bring her head to it; but if the engines are backed, she will throw her stern up to the sea exactly as she would to the wind, and this in spite of all that can be done to prevent it.

The longer the ship, the more decided will be the tendency to lie in the trough of the sea.

There may be special features of design or of the trim which will materially affect the steering of the ship. If she trims by the head, she may, when lying at rest with a beam wind, gradually throw her head up to it instead of her stern, although the chances are that the drag of the screw will prevent this.

If her after deadwood is cut away somewhat more than in ordinary designs, her hold upon the water will be reduced and there may be difficulty in holding her to a straight course. On the other hand, she will be very sensitive to small changes of helm, and will turn in small space, her stern being thrown off to leeward very decidedly by hard-over helm. Most of these points are well shown in connection with the Yashima, but it is stated that this ship steers very steadily, the reason for this being that her rudder, which is of unusually large area, is hung *beneath* the stern in such a way that, when, amidships, it takes the place of the deadwood which is cut away.

Effect of Shallow Water.—It is well known that ships do not manœuvre as well in shallow as in deep water, and it not infrequently happens that a vessel which steers perfectly in the open sea becomes very wild in channels where she has only a few feet of water under her keel. The explanation lies in the fact that the displaced water cannot flow off freely along the natural wave lines due to the shape of the under-water body. For similar reasons, the speed is reduced in shallow water as compared with that due to the same power in water deep enough to allow a free flow of the displaced water.

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The preceding sections, as carefully explained in the beginning, relate to ships of average characteristics in all respects. They illustrate principles which are broadly true of all ships, but which must be modified in one direction or another if we seek to apply them to ships of exceptional build, speed, trim or manœuvring power. This is illustrated in the turning curve of the Yashima, already referred to. The facts that her after deadwood is cut away much more than is usual, that her rudder is exceptionally large, and that her steering-gear admits of putting the helm over very quickly, result in an excessive "kick;" and this, coupled with the momentum due to high speed, results in the peculiarities which have been noted in her turning circle. If, in addition to the features just detailed, she were of light draft and flat bottom, certain of her peculiarities would be exaggerated still further, the conditions in such a case approximating to those involved in the turning of torpedo-boats, in which we have very high speed and extraordinary turning power associated with light draft and a floor comparatively flat. Such a boat, upon putting her helm hard over at full speed, turns sharply, but may drive along her original line even after she has turned her broadside nearly full towards it. In the manœuvring of such a craft as this, there is brought out strikingly another point which to a greater or less degree appears in all cases of turning. This is the outward heel of the ship, due to the momentum and the centrifugal force acting outward from the center, and to the lateral resistance of the water, which acts inward, but usually below the center of gravity, so that it adds to outward heel. These heeling forces are to some extent offset by the lateral water pressure on the rudder, which, acting on the inside, and below the center of gravity, has a tendency to produce inward heel. The heeling of large ships in turning is rarely of practical importance; but in torpedo-boats it may be a source of considerable danger. Suppose such a boat, whose build happens to be favorable for heeling, to be turning at full speed and with hard-over helm while at the same time rolling more or less in a seaway. The hard-over helm acts, as already noted, to counteract the other forces and reduce the outward heel. If, now, the helm is suddenly eased, this counteracting force is removed, and the boat lurches sharply outward; and if it happens that she is at the same instant rolled outward by an impulse from a wave, she may be unable to recover and may capsize.

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The forces thus far described as involved in the turning of a ship are all more or less under the control of those who must manœuvre her; or, if not under control, must be understood in order that she may be handled intelligently. They are thus properly matters of *Seamanship*. It will be interesting now to glance at a few points of a slightly different kind.

As the helm is put over, the ship begins to turn, or to acquire angular velocity, and for our present purpose we may consider the turning as taking place about the center of gravity of the ship. The turning is opposed by the resistance of the water to lateral displacement of the bow and stern; but as, in the beginning, this resistance is small—the turning being slow—the velocity of turning rapidly increases. This increase results in a still more rapid increase of resistance, and presently the two sets of forces, those producing and those opposing, the angular velocity, balance each other, and this velocity becomes constant. From this time on, the ship turns in a curve which is practically a circle, her bow maintaining a steady angle, technically known as the "drift angle," to the tangent of the circle.

An important point in connection with the turning of a ship has to do with what is known in mechanics as the "moment of inertia," of which we need only explain here that it depends upon the distribution of weights in the ship with reference to the center of gravity. The significance of this point may be made clear by a simple illustration. Suppose we have a long rod pivoted at its middle point (the center of gravity) and carrying on each side of the pivot a weight which may be moved in and out. If the weights are kept close in to the pivot, the rod will be easily turned and stopped; whereas if the weights are run out to the ends, a much greater effort will be required to start it, and, after it is started, to stop it. In the first case, the moment of inertia is small and the rod is easily controlled; in the second, the moment of inertia is large, and considerable force is required to control it. Similarly, ships with their weights near the ends have large moments of inertia and are more difficult to manœuvre than those whose weights are concentrated more nearly amidships, and whose moments of inertia are accordingly small.

It is important that all officers should be familiar with the manœuvring peculiarities of the ships which they are called upon to handle, and every effort should be made to determine and record these peculiarities at the very beginning of her service, a "ship's book" being kept, in which the results of all experiments are carefully entered. This book should contain the following information:

1. The turning circles of the ship, with starboard and port helm, and with different degrees of helm, carefully plotted to scale and showing the "kick," the "drift angle," the "tactical diameter," the "advance," the "transfer," etc.
2. The time and distance required to bring the ship to rest by backing with full power at several different speeds.
3. The behavior of the ship in stopping under the conditions of 2; whether the head goes to starboard or to port and how far.
4. The result of putting the helm over either way during the manœuvre of 2.
5. The effect upon this manœuvre of using a reserve of power for backing.
6. The effect upon this manœuvre of varying the time at which the helm is put over; before reversing the engines, after reversing, simultaneously with reversing.
7. The effect of wind in backing.
8. The best way to work helm and engines for turning in a limited space, and the shortest space in which the ship can be turned.

CHAPTER XIV.

RULES OF THE ROAD.

§ I.

INTERNATIONAL RULES.

Preliminary Definitions.

In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "steam-vessel" shall include any vessel propelled by machinery.

A vessel is "under way" within the meaning of these rules when she is not at anchor, or made fast to the shore, or aground.

II.—LIGHTS, AND SO FORTH.

The word "visible" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

Article 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-vessels—Masthead Light.

Art. 2. A steam-vessel when under way shall carry—(a) On or in front of the foremast, or if a vessel without a foremast, then in the forepart of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

Steam-vessels—Side-lights.

(b) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.[1]

[1] NOTE 1.—A very little consideration will show that these lights cannot be prevented from showing to some extent across the bow. The flame of the lamp must have a certain width, and the lamp as a whole must stand out at some distance from the inboard screen. In addition to this, there will always be a reflection, visible at a certain distance, from the outer (after) side of the light box. The mere use of a screen projecting three feet forward can do very little toward correcting this. The matter is a serious one, involving danger which is the greater because seldom realized. If we see all the lights of a steamer, we assume, and the law justifies us in assuming (see Art. 18), that she is heading directly toward us. But if her lights show a point across the bow, we may misjudge her course by a point; and if she makes a corresponding error with regard to our lights and our course, the situation may be one of grave danger.

Although this difficulty cannot be entirely done away with, it can be much reduced, by a batten of wood placed vertically along the forward edge of the fore and aft screen, and projecting out-board so that its outer edge shall be tangent to a line drawn through the inner edge of the wick, parallel to the keel line.

A light so screened will still show nearly or quite half a point across the bow, depending upon the width of the wick. This width is fixed by an English rule at "not less than one inch, nor more than two inches." A two-inch wick screened as above will show nearly 4° across the bow.

In inspecting the lights and their fittings, it is important to see that the after screen complies with the requirement that the light shall show only 2 points abaft the beam.

Steam-vessels—Range-lights.

(e) A steam-vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.[2]

NOTE 2.—The range-lights, as herein described, while giving far less information than they might be made to give if their position were more definitely fixed by law, are nevertheless so useful that it is to be hoped they may, before many years, be made compulsory for all steamers at all times when under way. They are at present compulsory within the interior waters of the United States for all other than "sea-going" steamers and ferry-boats. (See "Inland Rules" for United States. Art. 2. f.)

It is clear that, supposing a vessel carrying such lights to be seen on an even keel, the lights will show one above the other when she is heading toward the observer; that if she changes course, the lights will open out, the lower one (which is also the forward one), drawing away from the upper one, in the direction to which the ship's head is changing. If the position of the lights were definitely fixed by law, the angle of the line joining them would be an indication of the course steered; but since neither the vertical nor the horizontal distance between them is established, they cannot usually be regarded as giving much more information about the course than is given by side-lights. They have, however, one very great advantage over side-lights, in that, after being once clearly sighted, a change in their relative position gives instant notice of a change of course. This indication is especially sensitive when the vessel carrying the light is heading toward the observer, or nearly toward him, and this happens to be the point where the signals given by side-lights are often dangerously misleading. (See note 1.)

There is, of course, the farther very great advantage in range-lights over side-lights, that they can be seen at a much greater distance and thus give earlier notice as to the approximate course of the steamer carrying them. Their value would be considerably increased if we could be sure of finding associated with them the permanent white stern light *permitted* by the second part of Art. 10; but as the law stands, these two "permissive" clauses have no connection with each other, and we are not justified in assuming that a steamer which carries range-lights will also carry a permanent stern light.

It should be noted that when the vessel carrying range-lights is seen end-on, these lights may be confused with the lights of a vessel towing.

If the vessel carrying the range-lights has a list, this will be indicated, to an observer seeing her end-on, by the inclination of the side-lights.

Steam-vessels—When Towing.

Art. 3. A steam-vessel when towing another vessel shall, in addition to her side-lights, carry two bright white lights in a vertical line one over the other, not less than six feet apart,[3] and when towing more than one vessel shall carry an additional bright white light six feet above or below such light, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two[4] (a), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.[5]

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Note 3.—These lights may be confused with the range-lights of a steamer seen end-on. Moreover, the range-lights and towing-lights may be carried by the same vessel, which may thus, when seen end-on, show as many as four lights in a vertical line.

Note 4.—Under Art. 9 (b), fishing vessels off the European coast north of Cape Finisterre, carry, when fishing with drift-nets, two white lights, which may be confused with those of vessels towing. This calls for caution. A steamer in the neighborhood of a fishing ground, and having, perhaps, passed a number of fishing boats showing these lights, might easily fail to recognize a steamer towing, if she should chance to meet one.

Note 5.—That is to say, if two lights are carried, the lower one shall comply, as to height, with the requirements of Art. 2, for the regular masthead light; and if three are carried, the middle one shall comply with these requirements.

It is found that two lights separated by six feet blend into a single light at distances beyond about four miles.

Special Lights.

Art 4. (a) A vessel which from any accident is not under command shall carry at the same height as the white light mentioned in article two (a), where they can best be seen, and if a steam-vessel in lieu of that light, two red lights, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can best be seen, two black balls or shapes, each two feet in diameter.

(b) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in article two (a), and if a steam-vessel, in lieu of that light, three lights in a vertical line, one over the other, not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all around the horizon at a distance of at least two miles.[6] By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, three shapes not less than two feet in diameter, of which the highest and lowest shall be globular in shape and red in color, and the middle one diamond in shape and white.

Note 6.—The middle one of these lights, being white, will usually be seen before the others, and may be mistaken, until the other lights are seen, for a steamer's masthead light.

(c) The vessels referred to in this article, when not making way through the water, shall not carry the side-lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is not under command and can not therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in article thirty-one.

Lights for Sailing-vessels and Vessels in Tow.

Art. 5. A sailing-vessel under way and any vessel being towed shall carry the same lights as are prescribed by article two for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

Lights for Small Vessels.

Art. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side-lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Lights for Small Steam and Sail Vessels and Open Boats.

Art. 7. Steam-vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in article two (a), (b), and (c), but if they do not carry them they shall be provided with the following lights:

First. Steam-vessels of less than forty tons shall carry—

(a) In the forepart of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in article two (a), and of such a character as to be visible at a distance of at least two miles.

(b) Green and red side-lights constructed and fixed as prescribed in article two (b) and (c), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. Small steamboats, such as are carried by sea-going vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined lantern mentioned in subdivision one (b).

Third. Vessels under oars or sails of less than twenty tons shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by article four (a) and article eleven, last paragraph.

Lights for Pilot-vessels.

Art. 8. Pilot-vessels when engaged on their stations on pilotage duty shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon,[7] and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

Note 7.—This may be mistaken for a steamer's masthead light.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.[8]

Note 8.—In the waters of Great Britain and the United States, a steam pilot boat, when on duty and under way, carries, in addition to the lights herein prescribed, a red light, 8 feet below her white masthead light.

A pilot-vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above-mentioned, have at hand, ready for use, a lantern with green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot-vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

Lights, etc., of Fishing-vessels.

Art. 9. Fishing-vessels of less than twenty tons net registered tonnage, when under way, and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side-lights; but every such vessel shall in lieu thereof have ready at hand a lantern with a green glass on the one side and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.[9]

Note 9.—Observe that no lights are prescribed for vessels of this class when they *have* their nets, trawls, dredges or lines in the water, unless they are north of Cape Finisterre. In the absence of a special rule applying to such vessels, they must carry the lights of other vessels of their tonnage under way. But see page 243.

Lights for Fishing-vessels off European Coasts.

The following portion of this article applies only to fishing-vessels and fishing-boats when in the sea off the coast of Europe lying north of Cape Finisterre:[10]

NOTE 10.—A distinction is drawn here between two important methods of fishing.—*Trawlers*, *dredgers*, and *drag-net* fishers, run usually with the tide, dragging a net or scoop along the bottom. Their speed, under favorable circumstances, rarely exceeds two or three knots, and their power of manœuvring is of course very limited. These vessels are usually of considerable size (from 50 to 100 tons), and their work is carried on in deep water and often at great distances from shore. Such vessels show the lights of paragraph (c). If the trawl or dredge catches on the bottom, the vessel is virtually at anchor, and shows the regular anchor lights.

Fishing by *drift-nets* and *lines* is carried on by vessels drifting, and, of course, unable to manœuvre for the avoidance of collision.

Drift-nets are laid out with the wind, and the vessel rides head to wind to leeward of her nets, which may be as much as two miles in length, stretching off to windward, and buoyed at certain distances. *Lines* are laid out across the tide, and may be six or eight miles in length, marked at intervals by small buoys carrying flags. These buoys are not to float the line, but only to mark it. At the end of the line is a light anchor or other weight, which drags along the bottom, keeping the lines well down but not holding the boat.

Vessels fishing with either drift-nets or lines carry the lights of paragraph (b).

Drift-net fishing is principally done by night, line fishing by day, trawling by both night and day.

The methods of fishing to which this article applies are carried on by many thousands of vessels along the coasts of Europe north of Cape Finisterre, but the richest and most frequented grounds are in the North Sea.

(a) All fishing-vessels and fishing-boats of twenty tons net registered tonnage or upward, when under way, and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(b) All vessels when engaged in fishing with drift-nets shall exhibit two white lights from any part of the vessel where they can be best seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than ten feet, and so that the horizontal distance between them, measured in a line with the keel of the vessel, shall be not less than five feet and not more than ten feet. The lower of these two lights shall be the more forward, and both of them shall be of such a character and contained in lanterns of such construction as to show all around the horizon, on a dark night, with a clear atmosphere, for a distance of not less than three miles.

(c) All vessels when trawling, dredging, or fishing with any kind of drag-nets shall exhibit, from some part of the vessel where they can be best seen, two lights. One of these lights shall be red and the other shall be white. The red light shall be above the white light, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all around the horizon, on a dark night, with a clear atmosphere, the white light to a distance of not less than three miles and the red light of not less than two miles.[11]

(d) A vessel employed in line-fishing, with her lines out, shall carry the same lights as a vessel engaged in fishing with drift-nets.

(e) If a vessel when fishing with a trawl, a dredge, or any kind of drag-net, becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall show the light and make the fog-signal for a vessel at anchor.

(f) Fishing-vessels may at any time use a flare-up in addition to the lights which they are by this article required to carry and show. All flare-up lights exhibited by a vessel when trawling, dredging, or fishing with any kind of drag-net shall be shown at the afterpart of the vessel, excepting that if the vessel is hanging by the stern to her trawl, dredge, or drag-net they shall be exhibited from the bow.

(g) Every fishing-vessel when at anchor between sunset and sunrise shall exhibit a white light, visible all around the horizon at a distance of at least one mile.

(h) In a fog a drift-net vessel attached to her nets, and a vessel when trawling, dredging or fishing with any kind of drag-net, and a vessel employed in line-fishing with her lines out, shall, at intervals of not more than two minutes, make a blast with her fog-horn and ring her bell alternately.

NOTE 11.—These (International) Rules make no distinction between a steam trawler and a sailing trawler. Such a distinction is made by special laws governing British ships north of Cape Finisterre, and an elaborate and complicated system of lights is established. As the system is subject to change and will probably shortly be simplified, it is not given here.

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel a white light or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side-lights.

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length, when at anchor,[12] shall carry forward, where it can be best seen, but at a height not exceeding twenty feet above the hull, a white light in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, one such light, and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fair-way shall carry the above light or lights and the two red lights prescribed by article four (a).

NOTE 12.—A vessel is at anchor under the law when she is fixed by some means to the soil, when she is made fast to a buoy which is itself fixed to the soil, and when she is moored to a dock. (See the definition of "under way" in the preliminary clause of these rules.)

Special Signals.

Art. 12. Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these rules required to carry, show a flare-up light or use any detonating signal that can not be mistaken for a distress signal.[13]

> NOTE 13.—This may be very useful to attract the attention of a ship whose duty it is to keep clear, if she does not show a disposition to act. A detonating signal would be especially valuable, and such signals should be kept on the bridge. (See note 24.)

Naval Lights and Recognition Signals.

Art. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal-lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by ship owners, which have been authorized by their respective Governments and duly registered and published.

Steam-vessel under Sail by Day.

Art. 14. A steam-vessel proceeding under sail only but having her funnel up, shall carry in day-time, forward, where it can best be seen, one black ball or shape two feet in diameter.

III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

Preliminary.

Art. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam-vessels" on the whistle or siren.

Second. By "sailing-vessels" and "vessels towed" on the fog horn.

The words "prolonged blast" used in this article shall mean a blast of from four to six seconds' duration.

A steam-vessel shall be provided with an efficient whistle[14] or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn, to be sounded by mechanical means, and also with an efficient bell. (In all cases where the rules require a bell to be used a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small sea-going vessels.) A sailing-vessel of twenty tons gross tonnage or upward shall be provided with a similar fog horn and bell.

Note 14.—It is not easy to say what an "efficient" signal should be capable of doing; but we may probably insist that, under reasonably favorable conditions of wind and weather, a whistle should be heard not less than two miles, a fog horn and bell not less than one mile. It would, however, be dangerous to rely upon hearing signals at these or any other definite distances, so many and so seemingly erratic are the atmospheric conditions which modify the audibility of sound. A sound which, under most circumstances, would be clearly heard several miles, may, by some peculiar conditions of the atmosphere, be inaudible at a quarter of a mile. It is fairly well established, that sounds are heard rather better in a fog or snow than in clear weather (other things being equal); that sound travels better with the wind than against it; that a strong breeze breaks up all sounds, and that when the upper and lower strata of air are moving in contrary directions, sounds are particularly unreliable.

In fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

Steam-vessel under Way.

(a) A steam-vessel having way upon her shall sound, at intervals of not more than two minutes, a prolonged blast.[15]

Note 15.—It is clear that the blast from a whistle might be so prolonged or so frequent as to lessen unduly the probability of hearing a signal from another vessel. There is also, no doubt, some danger that the hearing of an officer on the bridge may be in a measure dulled by the too frequent sound of his own whistle.

It will be agreed by most seamen, however, that two minutes is much too long a time between signals; and the general practice of men-of-war and well regulated merchant steamers seems to be to make this interval, as nearly as may be, one minute, and to give the blast a length of from four to six seconds.

There are electrical devices on the market, by which the whistle is sounded automatically, at regular intervals and for a fixed length of time, thus relieving the officer of the watch and the quartermaster of all thought in the matter, and leaving them free to give their undivided attention to duties from which, in a fog, they never should be diverted.

The interval between signals is closely connected with the question of speed in a fog.

(b) A steam-vessel under way, but stopped, and having no way upon her, shall sound, at intervals of not more than two minutes, two prolonged blasts, with an interval of about one second between.[16]

Note 16.—The power to distinguish, in a fog, between a vessel moving and one stationary, is very important. Properly used, this signal should be interpreted by another vessel hearing it, to mean, "The way is off my ship; you may feel your way past me."

A caution is required in connection with the interval (two minutes) permitted between signals. The law probably intended to require that a steamer, having thus indicated that she is stationary, should remain so until she gives another signal and a different one—in other words, if a vessel which has been stationary, starts her engines, she should, by the time she gathers way, give the signal for a vessel moving, *without reference to the interval which has elapsed since her last signal.* Otherwise, she might gather way and actually move a considerable distance before indicating to vessels in her vicinity that she was no longer at rest and in the position where they would have every reason for placing her.

It is important to note that from the time two vessels sight each other, the sound signals of this article give way to the sound signals of Art. 28 for "Vessels in sight of each other."

Sail-vessel under Way.

(c) A sailing-vessel under way shall sound, at intervals of not more than one minute, when on the starboard tack, one blast; when on the port tack, two blasts in succession, and when with the wind abaft the beam, three blasts in succession.

Vessels at Anchor.

(d) A vessel when at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds.

Vessels Towing or Towed and Vessels Unable to Manœuvre.

(e) A vessel when towing,[17] a vessel employed in laying or in picking up a telegraph cable, and a vessel under way, which is unable to get out of the way of an approaching vessel through being not under command, or unable to manœuvre as required by the rules, shall, instead of the signals prescribed in subdivisions (a) and (c) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: One prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

NOTE 17.—Observe that a vessel towing is here classed with vessels unable to manœuvre in accordance with these rules when "in a fog, mist, falling snow, or heavy rainstorm." We shall see, however (Art. 16), that she is not relieved from the obligations laid upon other vessels, of running at a moderate speed, stopping in case of danger, and proceeding with caution; nor from any other of the obligations of these rules;—in short, the phrase "unable to manœuvre in accordance with these rules" must not be confounded with the phrase "not under command" in Article 4. This signal is a warning to vessels hearing it that they must not expect the vessel sounding it to manœuvre as they might otherwise expect her to do.

Small Sailing-vessels and Boats.

Sailing-vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but if they do not they shall make some other efficient sound signal at intervals of not more than one minute.

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a moderate speed, having careful regard to the existing circumstances and conditions.[18]

NOTE 18.—There is no point in connection with seamanship or admiralty law about which there has been as much discussion as about this question of "moderate speed" in a fog. The debates on it fill a hundred pages or more in the report of the International Marine Conference by which the present rules were drawn up. It was contended that a law upon which so much depended ought not to be left open to any doubt; and that the maximum speed at which a vessel might run in a fog should be definitely fixed by a law which no one could violate except willfully and at his peril.

This subject will be treated as a matter of seamanship in a later chapter. As a matter of law, it may be said that the courts of both England and America have held that "moderate" speed is such speed as will enable a vessel to avoid collision with any other vessel which she may find herself near. This is the phrase of a lawyer rather than of a seaman; but while unquestionably vague, it conveys fairly well the meaning intended. In a dense fog, it calls for the very lowest speed which is consistent with steerage way; and steamers have been found at fault when running less than five knots. If the fog is so dense that a ship which has barely steerage way and a good reserve of power cannot see another in time to avoid her even at that low speed, then the law requires vessels to stop, and, if circumstances permit it, to anchor. This is unquestionably the *law* in the matter, and we are not at present considering its wisdom, or the general practice of seamen in connection with it.

On the other hand, it has been held by the courts of both England and the United States that a higher speed is permissible in the open sea, where the probability of falling in with other ships is very slight, than in crowded waters or on fishing grounds. When in the neighborhood of shoals and particularly in channels where currents are strong and unknown, it may be dangerous to slow beyond a certain point, and a court would doubtless accept such a plea as a valid reason for maintaining a speed which under other circumstances would be excessive. This is fully covered by the phrase "having careful regard to the existing circumstances and conditions." But the burden of proof is thrown upon the ship maintaining such speed. There can be no question that the custom commonly followed by the great ocean liners, of running through dense fogs at a speed only a few knots below their maximum, is, in the eyes of the law, altogether unjustifiable.

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel, the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.[19]

NOTE 19.—It should be noted that the *ship* need not be stopped immediately, but the *engines* must be. If, later, the danger appears such that the ship should be stopped, there will be a reserve of steam ready for backing hard. The objection to backing the engines before the location of the danger is fixed, is that by doing so the control of the ship by the helm is to a great extent destroyed.

IV.—STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.[20]

NOTE 20.—The principle involved here is an excellent and a very important one; but the thought of taking careful compass bearings at night, in the presence of possible danger, will probably not appeal favorably to most seamen. The practical way to make these observations is to stand at a point from which the compass can be watched, and then, taking care that a steady course is steered, bring the other vessels or light "on" with a point of the rigging or the rail, and watch thus for a change in its bearing.

There are, of course, many cases in which there is no time to wait for a change in bearing; but in cases of such emergency as this, the ships are close enough together to make the danger clear at a glance, and there is rarely more than one course of action that can give a hope of safety.

Sailing-vessels.

Art. 17. When two sailing-vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

(b) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.[21]

NOTE 21.—These rules are simple and satisfactory when the situations to which they apply are clearly defined. But in practice it is often impossible for *A* to tell with any degree of certainty whether *B* is close hauled or a little free; and yet the action to be taken by *A* may depend upon this and this alone.

A similar difficulty arises when *A*, running with the wind free on the port hand, sights *B*, to port and running free, and cannot tell on which side *B* has the wind. If she has it on the starboard side, *A* must keep clear, under rule (c); if on the port side, *A* has the right of way and *B* must keep clear under rule (d), because she is to windward of *A*.

No doubt a rational interpretation of this rule would require *B* to keep clear in most of these doubtful cases, on the ground that she would have the wind so nearly aft that it should be considered aft in the meaning of the law.

An officer taking charge of the deck of a sailing ship should estimate carefully the true direction of the wind and consider what conclusions may be based upon this with regard to the possible or probable course of other vessels whose lights may be sighted ahead or on either hand. Remembering that a square rigger cannot lie closer to the wind than 6 points and that side-lights show through a range of ten points, from right ahead to two points abaft the beam, he will have much information upon which to base an opinion as to the way in which a ship may be heading which is seen on a given bearing, showing a red or green light. If his own ship is close-hauled on the port tack, he has the right of way over all other vessels except one close-hauled on the starboard tack, and it is clear that such a vessel, to threaten collision, must bear a little on the lee bow and must show a red light. In a similar way, deductions may be drawn from the data available in any given case, and, usually, a line of bearing may be decided upon, with reference to which it may be said that, broadly speaking, it is right to stand on for all *crossing* lights seen on one side of this line, and to give way to all *crossing* lights seen on the other side.

This idea has been worked out very completely and put in convenient form for reference by Captain H. S. Blackburne, in a little pamphlet entitled "Diagrams with explanations illustrating the Rules of the Road for sailing Ships."

Steam-vessels.

Art. 18. When two steam-vessels are meeting end-on, or nearly end-on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end-on, or nearly end-on, in such a manner as to involve the risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end-on or nearly end-on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line or nearly in a line with her own; and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.[22]

NOTE 22.—Here, again, we have to do with rules which are simple, applied to a situation which seems simple, but which, in fact, is very far from being so.

In spite of the requirement of Art. 2, that side-lights shall not show across the bow, it is perfectly well known that they do show across, frequently as much as a point and, in extreme cases, even more than this.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.[23]

NOTE 23.—Watchfulness is called for in the case of a green light a little on the starboard bow. This situation should be one of safety, but danger is introduced by the inclination which nervous officers frequently have, to put the helm aport. Many seamen of experience consider a green light a little on the starboard bow the most serious threat of collision with which they have to deal.

Two Steam-vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

Steam-vessels shall keep out of the Way of Sailing-vessels.

Art. 20. When a steam-vessel and a sailing-vessel are proceeding in such directions as to involve risk of collision, the steam-vessels shall keep out of the way of the sailing-vessel.

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way the other shall keep her course and speed.

Note. When, in consequence of thick weather or other causes, such vessel finds herself so close that collision can not be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision. (See articles twenty-seven and twenty-nine.)[24]

NOTE 24.—One of the most trying positions in which an officer can find himself is that of holding on with a prospect of collision where the other vessel ought to keep clear but takes no action to do so. The impossibility of knowing whether the giving-way ship intends to act, and if so when, and the necessity of deciding when the time has come which will justify the holding-on ship in acting under this article make the situation very difficult.

The use of a detonating signal, as per article 12, may be helpful here.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.[25]

NOTE 25.—This article is one of the most important in the Rules of the Road, to which it was added by the International Conference of 1889.

Taken in connection with Art. 19 and with the new provision of Art. 21, by which the vessel having the right of way is required to keep her speed as well as her course, it defines very clearly the manœuvre for steamers crossing, and requires, as a matter of law, what has always been the practice of careful and competent seamen.

Steam-vessels shall slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.[26]

Note 26.—The English Courts having held that a tug towing another vessel at a speed of 1½ knots was not at fault for not stopping altogether (although by so doing she might have averted collision), because, had she done so, there would have been danger of the tow running down the tug and of the line fouling the tug's propeller.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

Narrow Channels.

Art. 25. In narrow channels every steam-vessel shall, when it is safe and practicable, keep to that side of the fair-way or mid-channel which lies on the starboard side of such vessel.

Rights of Way of Fishing-vessels.

Art. 26. Sailing-vessels under way shall keep out of the way of sailing-vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

General Prudential Rule.

Art. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

Sound-signals for Vessels in Sight of One Another.[27]

Art. 28. The words "short blast" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam-vessel under way, in taking any course authorized or required by these rules, shall indicate that course by the following signals on her whistle or siren, namely:

One short blast to mean, "I am directing my course to starboard."

Two short blasts to mean, "I am directing my course to port."

Three short blasts to mean, "My engines are going at full speed astern."

NOTE 27.—It should be noted that this rule applies to vessels in sight of each other, whether by night or day, in clear or in foggy weather, but not to vessels, however close, which do not see each other or each other's lights. Thus two vessels in a fog must keep to the signals of Art. 15 until they actually see each other. Many seamen hold that there would be great advantage in the use of these signals by vessels near each other, but not in sight, in a fog, and some officers do not hesitate to use them in this way; but this is in direct defiance of the law.

No Vessel, under any Circumstances, to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by special circumstances of the case.

Reservation of Rules for Harbors and Inland Navigation.

Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland waters.[28]

NOTE 28.—In the waters of the United States there are two sets of rules "duly made by local authority"; 1st, the so-called "Inland

Rules" made by Act of Congress; 2nd, the special rules made by the inspectors of steam-vessels, under the provision of Act 5, section 2 of the Inland Rules.

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N. C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. Flames on the vessel as from a burning tar barrel, oil barrel, and so forth.

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

§ II.

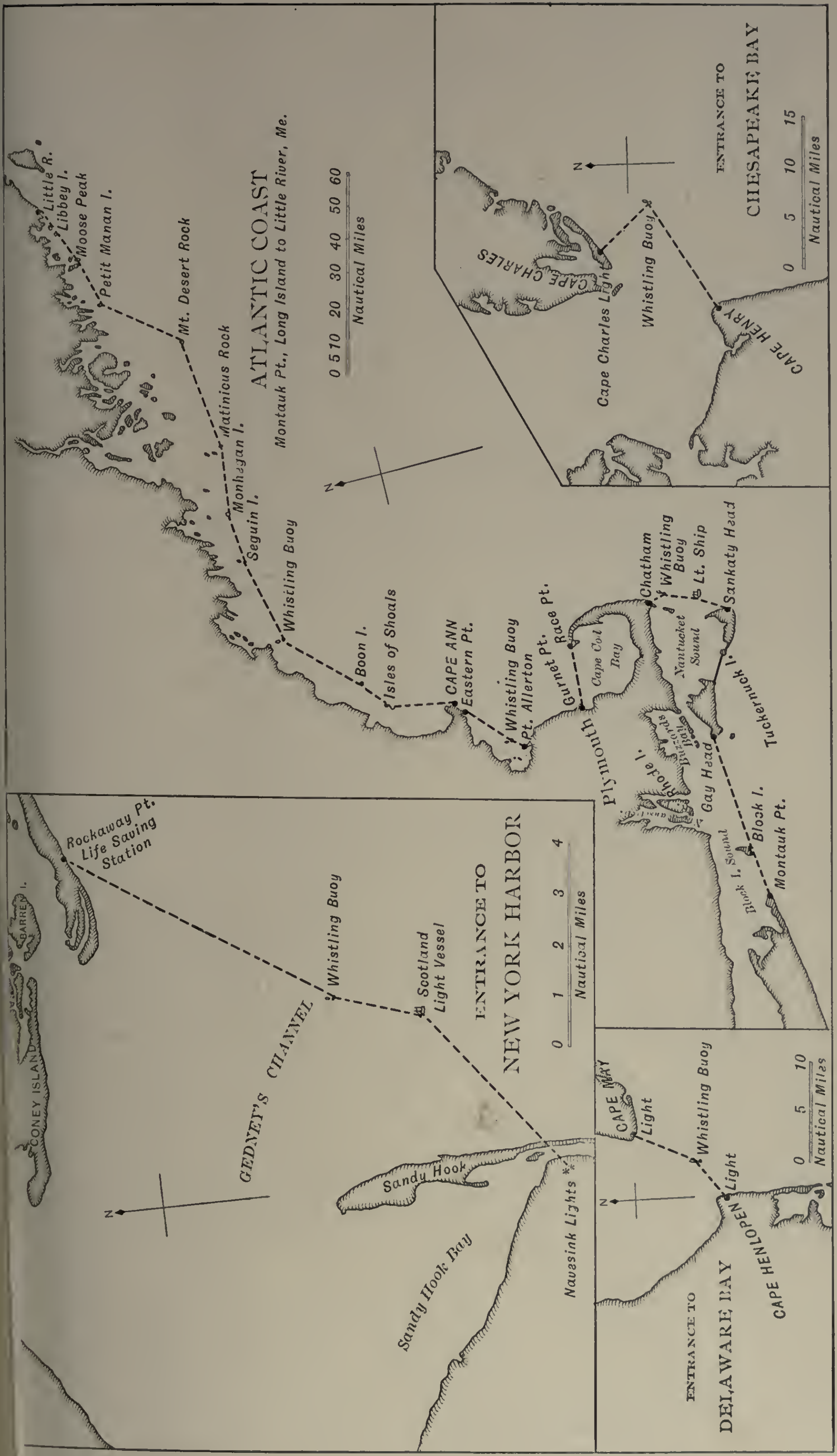
RULES FOR INLAND WATERS OF THE UNITED STATES.

These rules apply to all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries.

The boundary lines of the waters included are shown in the charts of Plate **95**.

These rules agree with the International Rules except in the points below noted. This section should be compared with the preceding one. Certain of the most important Articles are repeated here for convenience, even when they do not differ from the corresponding Articles of the International Rules.

Plate No. 95.



INLAND RULES OF THE ROAD

- - - - - - This dotted line represents demarkation between Inland and International Rules.

II.—LIGHTS, AND SO FORTH.

In the Inland Rules (Art. 2), the height at which the masthead light shall be carried is not specified.

The section relating to range-lights reads as follows:

Steam-vessels—Range-lights.

(e) A sea-going steam-vessel when under way may carry an additional white light, similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(f) All steam-vessels (except sea-going vessels and ferry-boats) *shall* carry in addition to green and red lights required by article two (b), (c), and screens as required by article two (d), a central range of two white lights, the after-light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The head-light shall be so constructed as to show an unbroken light through twenty points of the compass, namely, from right ahead to two points abaft the beam on either side of the vessel, and the after-light so as to show all around the horizon.

The Inland Rules for Towing lights are as follows:

Steam-vessels—When Towing.

Art. 3. A steam-vessel when towing another vessel shall, in addition to her side-lights, carry two bright white lights in a vertical line, one over the other, not less than *three* feet apart, and when towing more than one vessel, shall carry an additional bright white light *three* feet above or below such lights, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a) *or the after range-light mentioned in article two* (f).

Such steam-vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

The special lights prescribed by the International Rules (Art. 4) for vessels not under command and for vessels laying and picking up telegraph cables are not recognized by the Inland

Rules. Such vessels therefore carry the lights of other vessels under way.

The lights for sailing-vessels and vessels in tow are as follows:

Lights for Sailing-vessels and Vessels in Tow.

Art. 5. *A sailing-vessel under way or being towed* shall carry the same lights as are prescribed by article two for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

Note that there are no lights specified for steamers being towed. As a matter of fact, such vessels carry the same lights as sailing-vessels being towed.

The following section is added to this article in the Inland Rules:

Lights for Ferry-Boats, Barges, and Canal-boats in Tow.

Section 2. That the supervising inspectors of steam-vessels and the Supervising Inspector-General shall establish such rules to be observed by *steam-vessels in passing each other*, and as to the lights to be carried by ferry-boats and by barges and canal-boats when in tow of steam-vessels, not inconsistent with the provisions of this Act, as they from time to time may deem necessary for safety, which rules, when approved by the Secretary of the Treasury, are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall be furnished to such ferry-boats and steam-vessels, which rules shall be kept posted up in conspicuous places in such vessels.

The special rules adopted under Section 2 are published by the Treasury Department in a pamphlet entitled "Pilot Rules for Atlantic and Pacific Coast Waters." The rules referring to steamers passing will be given in connection with Article 18.

The lights of barges and canal-boats in tow of steamers are in substance as follows:

"In the Hudson River from Troy to Sandy Hook, the East River and Long Island Sound, to and including Narragansett Bay," barges and canal-boats carry white lights at bow and stern. Where a number of them are massed in one or more tiers, the limits of the tow are marked by white lights carried at the bows of the outside boats and an additional white light at the stern of each of the two outside boats of the last tier.

In all other waters than those above-named, barges and canal-boats carry colored side-lights; and where they are massed in tiers, these lights are carried at the bows of the outside barges of each tier.

Art. 6, which permits the use of portable lights by small vessels in bad weather is retained in the Inland Rules, but Art. 7, which authorizes special lights for small steam and sail-vessels, is omitted with the exception of the paragraph relating to rowing-boats.

The Inland Rules for pilot vessels (Art. 8) are the same as the International Rules except in the case of steamers, the lights for which are prescribed by the following Act of Congress, approved February 19, 1900:

A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side-lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above mentioned, but not the colored side-lights.

When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

All of that part of Art. 9 relating to "Fishing-vessels off European Coasts" is omitted from the Inland Rules, and the following is added:

(b) All fishing-vessels and fishing-boats of ten gross tons or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(c) All vessels, when trawling, dredging, or fishing with any kind of drag-nets or lines, shall exhibit, from some part of the vessel where they can be best seen, two lights. One of these lights shall be red and the other shall be white. The red light shall be above the white light, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all round the horizon, the white light a distance of not less than three miles and the red light of not less than two miles.

Lights for Rafts or other Craft not Provided for.

(d) Rafts, or other water craft not herein provided for, navigating by hand-power, horse-power, or by the current of the river, shall carry one or more good white lights, which shall be placed in such manner as shall be prescribed by the Board of Supervising Inspectors of Steam Vessels.

The lights for an overtaken vessel (Art. 10) are substantially the same as in the International Rules.

The lights for a vessel at anchor (Art. 11) are the same as in the International Rules except that no lights are prescribed for "a vessel aground in or near a fairway." Such a vessel must, therefore, in Inland Waters, show the lights of a vessel at anchor.

Articles 12 and 13, permitting the use of special signals to attract attention, and of Naval lights and Recognition signals, are retained in the Inland Rules.

A steamer proceeding under sail with her smokestack up (Art. 14) is permitted, *not required*, to show a black ball or shape two feet in diameter.

III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

The clause of Art. 15 relating to a steam-vessel under way reads as follows in the Inland Rules:

Steam-vessel Under Way.

(a) A steam-vessel *under way* shall sound, at intervals of not more than *one* minute, a prolonged blast.

Note the distinction between "a vessel under way" and a vessel "having way upon her."

Subdivision (b) of the International Rules is omitted in the Inland Rules, which prescribe no signal for a steamer stopped. Such a steamer must, therefore, in inland waters, give the signal of a vessel under way.

The Sound Signals for a sailing-vessel under way and for a vessel at anchor are the same as in the International Rules.

The signals for a vessel towing or towed are as follows:

(e) A *steam*-vessel when towing, shall, instead of the signals prescribed in subdivision (a) of this article, at intervals of not more than *one* minute, sound three blasts in succession, namely, one prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

Note that no special signal is provided for a vessel not under command nor for a vessel laying or picking up a telegraph cable. Such vessels must use the same signals as other vessels.

Article 16, although the same as in the International Rules, is repeated here.

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

IV.—STEERING AND SAILING RULES.

The rules for sailing-vessels approaching each other (Art. 17) are the same as in the International Rules.

The rules for steam-vessels meeting are as follows: *They differ in important particulars from the International Rules.*

Art. 18. Rule I. When steam-vessels are approaching each other head and head, that is, end-on, or nearly so, it shall be the duty of each to pass on the port side of the other; and either vessel shall give, as a signal of her intention, one short and distinct blast of her whistle, which the other vessel shall answer promptly by a similar blast of her whistle, and thereupon such vessels shall pass on the port side of each other. But if the courses of such vessels are so far on the starboard of each other as not to be considered as meeting head and head, either vessel shall immediately give two short and distinct blasts of her whistle, which the other vessel shall answer promptly by two similar blasts of her whistle, and they shall pass on the starboard side of each other.

The foregoing only applies to cases where vessels are meeting end-on or nearly end-on, in such a manner as to involve risk of collision; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course, or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

Rule V. Whenever a steam-vessel is nearing a short bend or curve in the channel, where, from the height of the banks or other cause, a steam-vessel approaching from the opposite direction can not be seen for a distance of half a mile, such steam-vessel, when she shall have arrived within half a mile of such curve or bend, shall give a signal by one long blast of the steam-whistle, which signal shall be answered by a similar blast, given by any approaching steam-vessel that may be within hearing. Should such signal be so answered by a steam-vessel upon the farther side of such bend, then the usual signals for meeting and passing shall immediately be given and answered; but, if the first alarm signal of such vessel be not answered, she is to consider the channel clear and govern herself accordingly.

When steam-vessels are moved from their docks or berths, and other boats are liable to pass from any direction toward them, they shall give the same signal as in the case of vessels meeting at a bend, but immediately after clearing the berths so as to be fully in sight they shall be governed by the steering and sailing rules.

Rule VIII. When steam-vessels are running in the same direction, and the vessel which is astern shall desire to pass on the right or starboard-hand of the vessel ahead, she shall give one short blast of the steam-whistle, as a signal of such desire, and if the vessel ahead answers with one blast, she shall put her helm to port; or if she shall desire to pass on the left or port side of the vessel ahead, she shall give two short blasts of the steam-whistle as a signal of such desire, and if the vessel ahead answers with two blasts, shall put her helm to starboard; or if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving several short and rapid blasts of the steam-whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.

Rule IX. The whistle signals provided in the rules under this article, for steam-vessels meeting, passing, or overtaking, are never to be used except when steamers are in sight of each other, and the course and position of each can be determined in the day-time by a sight of the vessel itself, or by night by seeing its signal lights. In fog, mist, falling snow or heavy rainstorms, when vessels can not so see each other, fog-signals only must be given.

The following rules belong with the preceding, but are not a part of the Act of Congress. They are rules made by the Supervising Inspectors of Steam-vessels under the provisions of Article 5, Section 2:

Rule II. When steamers are approaching each other in an oblique direction, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other, which latter vessel shall keep her course and speed; the steam-vessel having the other on her starboard side indicating by one blast of her whistle her intention to direct her course to starboard, and two blasts if directing her course to port, to which the other shall promptly respond, but the giving and answering signals by a vessel required to keep her course shall not vary the duties and obligations of the respective vessels.

Rule III. If when steam-vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving several short and rapid blasts, not less than four, of the steam-whistle; and if the vessels shall have approached within half a mile of each other, both shall be immediately slowed to a speed barely sufficient for steerage-way until the proper signals are given, answered, and understood, or until the vessels shall have passed each other.

Vessels approaching each other from opposite directions are forbidden to use what has become technically known among pilots as "cross signals"—that is, answering one whistle with two, and answering two whistles with one. In all cases, and under all circumstances, a pilot receiving either of the whistle signals provided in the rules, which for any reason he deems injudicious to comply with, instead of answering it with a cross signal, must at once observe the provisions of this rule.

Rule VI. The signals, by the blowing of the whistle, shall be given and answered by pilots, in compliance with these rules, not only when meeting "head and head," or nearly so, but at all times when passing or meeting at a distance within half a mile of each other, and whether passing to the starboard or port.

Rule VII. When two steamers are approaching the narrows known as "Hell Gate," on the East River at New York, side by side, or nearly so, running in the same direction, the steamer on the right or starboard hand of the other (when approaching from the west), when they shall have arrived abreast of the north end of Blackwells Island, shall have the right of way, and the steamer on the left or port side shall check her way and drop astern. In like case when two steamers are approaching from the east, and are abreast of Negro Point, the steamer on the right or starboard hand of the other shall have the right of way, and shall proceed on her course without interference, and the steamer on the port side of the other shall keep at a safe distance astern (not less than three lengths) until both steamers have passed through the difficult channel.

The following, although identical with the International Rule, is repeated here:

Two Steam-vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

But see Rule II under Article 18 above.

Art. 20, requiring a steamer to keep clear of a sailing-vessel is the same as in the International Rules.

Art. 21 reads as follows:

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way, the other shall keep her course and speed.

Observe that the note which in the International Rules directs the holding on ship to manœuvre for the avoidance of collision in case of an emergency, is omitted in the Inland Rules. *But see Articles 27 and 29 below.*

The following, although identical with the International Rules, are repeated here:

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

Steam-vessel shall Slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

The rule and definitions for overtaking vessels (Art. 24) are the same as in the International Rules.

The rule for narrow channels (Art. 25) and the requirement that sailing-vessels shall keep clear of fishing-vessels (Art. 26) are the same as in the International Rules.

The following important rule, although identical with the International Rule, is repeated here:

General Prudential Rule.

Art. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

The sound signals for vessels in sight of one another in the Inland Rules are as follows:

Sound Signals for Vessels in Sight of One Another.

Art. 28. When vessels are in sight of one another a steam-vessel under way whose engines are going at full speed astern shall indicate that fact by three short blasts on the whistle.

The signals for changes of course are prescribed in Rule II under Article 18 above.

Article 29 is the same as in the International Rules.

No Vessel under any Circumstances to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Article 30 in the Inland Rules reads as follows:

Art. 30. The exhibition of any light on board of a vessel of war of the United States or a revenue cutter may be suspended whenever, in the opinion of the Secretary of the Navy, the commander-in-chief of a squadron, or the commander of a vessel acting singly, the special character of the service may require it.

Signals of Distress in Inland waters are as follows:

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the Daytime.

A continuous sounding with any fog-signal apparatus, or firing a gun.

At Night.

First. Flames on the vessel as from a burning tar barrel, oil barrel and so forth.

Second. A continuous sounding with any fog-signal apparatus, or firing a gun.

. . . .

A note to the "Pilot Rules for Atlantic and Pacific Coast Inland Waters" reads as follows:

"N. B.—The foregoing rules are to be complied with in all cases, except when steamers are navigating in a crowded channel, or in the vicinity of wharves; under such circumstances steamers must be run and managed with great caution, sounding the whistle, as may be necessary, to guard against collision or other accidents."

This applies to the whole of the present section.

It will be seen that there is here an important modification of the ordinary law.

§ III.

INLAND RULES OF NATIONS OTHER THAN THE UNITED STATES.

The Inland Rules of other countries do not exist in a form which admits of convenient grouping. In many cases the rules are made locally for each port or river.

Officers having to navigate the inland waters of any country should use every effort to acquaint themselves with these local laws. In some cases they are to be found in Sailing Directions, in others they must be learned from pilots or other local authorities.

§ IV.

LAWS RELATING TO THE RULES OF THE ROAD.

Penalties are prescribed for the infringement of these rules, by all nations which have adopted them as laws, and these penalties do not depend upon the question whether damage has or has not resulted from the infringement.

Where damage is done, and can be shown to be the result of neglect or violation of the rules, it is held, in the absence of proof to the contrary, to be the fault of the person having charge of the deck of the vessel offending, who will be considered guilty of a misdemeanor and punishable therefor. If death ensues, he will be subject to a charge of manslaughter.

In every case of collision, it is the duty of the person in charge of each vessel, to stay by the other and to render such assistance as may be practicable, provided he can do so without damage to his own ship, passengers and crew.

He is also required to give to the master of the other ship the name of his own ship and of the port to which she belongs, and the ports to and from which she is bound.

As soon as possible after the collision, he must cause an entry to be made in the log book, of the collision and of all facts in connection with it.

CHAPTER XV.

MANŒUVRING TO AVOID COLLISION.

§ I.

The difficulties and dangers with which this chapter has to deal are principally connected with darkness and with fog. In daylight and in clear weather, the avoidance of collisions should be simple enough. This chapter will therefore deal, first, with steamers meeting or crossing at night, and later, with the more difficult question of manœuvring in a fog.

As an aid in determining accurately the bearing of a light sighted at night, and of readily recognizing a change in this bearing, it is convenient to have installed, close to the bridge compass, a "pelorus" or dumb-compass, marked to degrees and to quarter points, accurately adjusted with its zero in the fore-and-aft line of the ship, and with a sighting-vane pivoted at the center.

It is well also to establish a clearly marked fore-and-aft line from a convenient point on each side of the bridge to some conspicuous point near the bow, by which the line on which the ship is heading may be picked up at a glance.

§ II.

Steamers Meeting.

Attention has already been called to the fact that this situation is not as simple as it at first appears, for the reason that vessels which seem to be approaching each other "end-on or nearly end-on," may in fact be crossing at a considerable angle.

There is no rule which can be laid down to eliminate the danger of such misunderstanding; but there is a certain gain in recognizing the existence of the danger and the necessity for watchfulness. If the helm is to be put to port, this should be done while the ships are separated by a perfectly safe distance, and the course changed to starboard sufficiently to make sure of shutting out the green light from the view of the other ship.[1] It is of course impossible to do this in a narrow channel, nor will it be important to do it there, as each vessel will know the course that the other must be steering; but the change of course should always be made as early as the channel permits.

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[1] See Note 23, Art. 18 of chapter "Rules of the Road."

Plate No. 96.

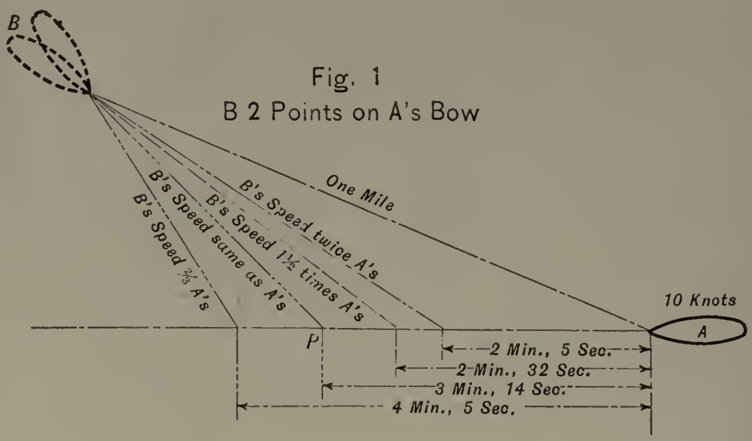


Fig. 1
B 2 Points on A's Bow

The time Intervals shown assume A's speed as 10 Knots, but can be easily corrected for any other speed.

Ships are not drawn to scale.

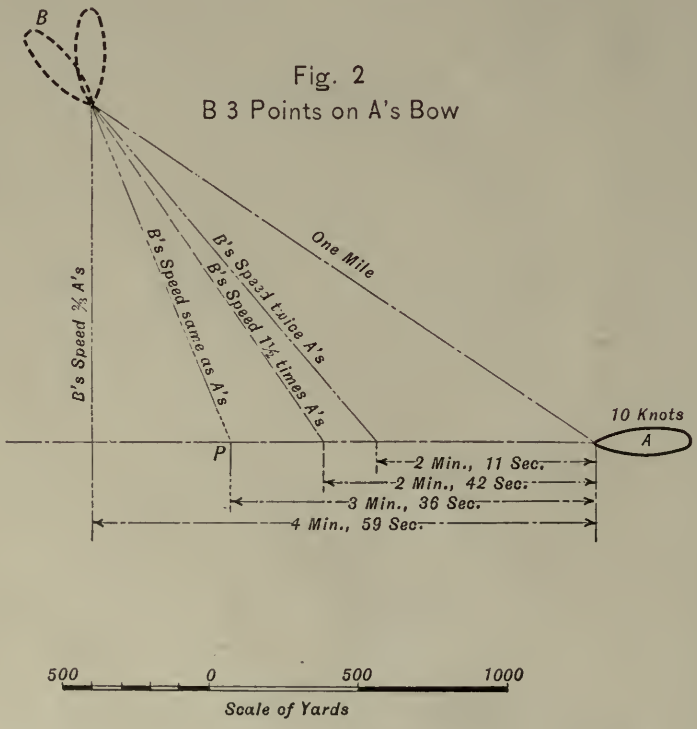


Fig. 2
B 3 Points on A's Bow

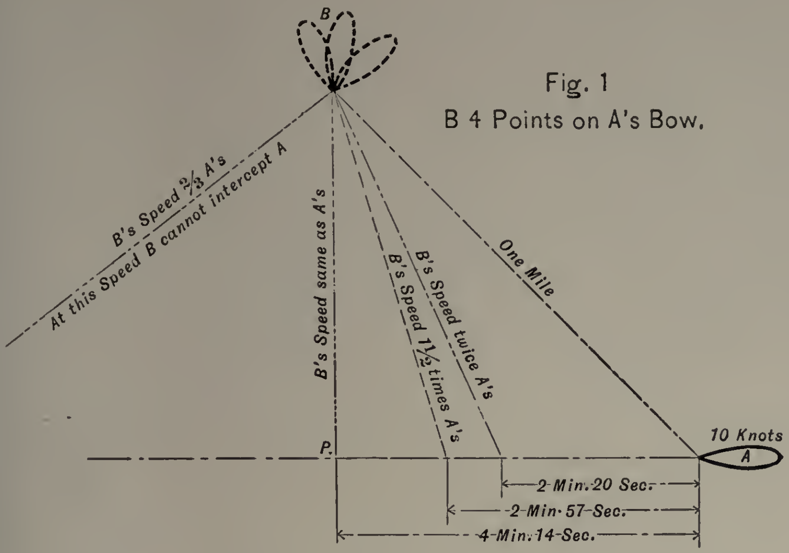
MANOEUVRING TO AVOID COLLISION.

Showing the points at which A and B will meet for various relative speeds.

Plate No. 97.

Fig. 1

B 4 Points on A's Bow.

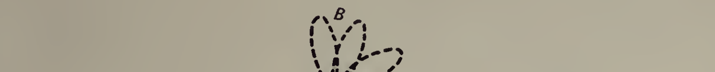


The time intervals shown, assume A's speed as 10 knots, but can be easily corrected for any other speed.

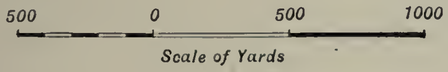
Ships are not drawn to scale.

Fig. 2

B 5 Points on A's Bow.



Showing the points at which A and B will meet, for various relative speeds.



MANOEUVRING TO AVOID COLLISION

When meeting another vessel in a narrow channel, there is danger in changing course too much, as to do so opens the broadside to a possible blow from the other ship. A small change made promptly, is safer than a greater change made after the ships are close aboard. On the other hand, there is the danger already pointed out, that, at night, a small change of course will not be seen by the other ship. In this situation, range-lights are especially valuable, as giving instant notice of the slightest change in the heading of a vessel seen end-on or nearly so.

In navigating crowded channels, pilots try to avoid changing course; preferring, whenever it can be done with safety, to keep clear of other vessels by reducing or increasing speed. This is less confusing than changes of course where several vessels are trying to keep clear of each other.

§ III.

STEAMERS CROSSING.

Note.—In this section, the steamer having the other on her own starboard hand is called A; *the other* B.

As preliminary to a detailed discussion of cases arising under this heading, attention is directed to the figures of Plates **96** and **97**, in which the vessels are assumed to be separated by one mile, and the courses plotted which B must be steering, for various rates of speed, in order that there shall be danger of a bow-to-bow collision with A.[1]

We do not attempt here to draw any conclusions which involve a knowledge on the part of either vessel, of the course or speed of the other.

It is apparent from these figures that, if there is to be a collision, the point at which it will take place depends upon the relative speed of the two ships. If the speeds are equal, it will be at P, equidistant from A and B. If B has the greater speed, the point of meeting is crowded back towards A, and the space available for A to manœuvre is reduced. If, on the other hand, B's speed is less than A's, the point of intersection recedes, and the space at A's command is correspondingly increased. It follows from this that if A is running at a low speed and finds another vessel closing in on her without change of bearing, she will know that the space at her command for manœuvring is comparatively limited, as, in all probability, the point of intersection of the courses is not far ahead.

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[1] We cannot, of course, disregard the length of the ships; but as a basis of argument we deal here with the bows only. The figures will make it clear in what way the argument must be modified to include the meeting of the bow of one ship with the stern of the other.

As regards B, if it happens that she is running at very high speed, she, too, will know that in all probability the courses intersect near A and that A has probably but little space for clearing her (B's) line. It may therefore be urged that, so far as B is concerned, the obligation upon her to act for the avoidance of collision, under Art. 21 of the Rules of the Road, will increase with her speed; that is to say, if her speed is so high that A's is not likely to equal it, she will know that her course is *probably* crossing A's at a point which leaves A but little space in which to manœuvre for mutual safety.

As regards the *time* available in the cases illustrated in Plates **96** and **97**, we cannot discuss this without assuming a definite speed for A. In the figures, this is taken at 10 knots, so that B's speed becomes, for the courses laid down, 10, 15, 20 and 7 knots.

If A's speed is greater or less than 10 knots, the intervals must be changed correspondingly.

If we take the distance between the ships as greater or less than one mile, the scale of the figures must be changed.

With these speeds, we see that, when B is distant one mile and crossing without change of bearing, the bows of the two ships will meet after the intervals shown in the figures.

An important point brought out by the figures is that, if B's speed is materially less than A's, there are only certain bearings on which B can threaten collision. Suppose, for example, that B's speed is two-thirds of A's, and that she bears four points on A's bow. She cannot by any possibility reach the line of A's course in time to intercept and collide with her. As the difference in speed increases, this point comes out more and more strikingly. If A's speed is three times B's, there can be no collision if B is sighted more than 1¾ points on the bow.

It follows from this, that in the case of a steamer running at a speed so high that no vessel which is likely to cross her course can be expected to have anything like an equal speed, the danger sector is confined to a few points on either bow.

Take the case of an ocean liner, running at a speed of 20 knots, and consider her relation, for example, to sailing-vessels crossing her route. These vessels will not have more than one-third to one-half her speed. To threaten collision, then, they must bear a very little on the bow, and can be cleared, in most cases, with a few spokes of the helm. Although this point is not usually specifically brought out, it is probably somewhat vaguely held as the basis of the contention so strongly insisted upon by the officers of the great liners, that it is safer for them to run at full speed in a fog than to slow down. This subject will be discussed in a later section, in connection with "Fog," and it will be shown that this is only one of many points to be considered in thick weather, and that the unquestionable advantage of high speed from this point of view is much more than counterbalanced by other considerations.

§ IV.

A large proportion of steamers meeting at sea approach each other on bearings from ahead to four points on the bow. It happens that this is, for reasons which will appear hereafter, the most dangerous bearing on which they can approach; and it results from this coincidence of the maximum frequency of occurrence with the maximum of danger, that something like seventy-five per cent of all collisions reported, are between vessels approaching each other on these bearings.

It will be convenient to distinguish two general classes of situations: *1st*, Those arising under ordinary conditions, where vessels sight each other at normal distances and have plenty of time and space for manœuvring to avoid collision; and *2nd*, Those in which they do not see each other until dangerously close. If any doubt exists as to whether they are dangerously close or not, it should of course be assumed that they are.

1st. Masthead lights are required by law to be visible five miles, on a clear, dark night; and this law is fairly well complied with. We shall certainly not be in error if we assume that they will show four miles, and that the side-lights of a steamer will show half as far. If bearings are taken from the time the masthead lights are seen, the situation should be perfectly clear by the time the side-lights are made out, and if danger of collision has been found to exist, A (the "giving way" ship) should be ready to act at once. She may give way by changing speed, or course, or both, but it is always simpler to change the course than to reduce the speed materially; and this has the further advantage that it gives notice to B of what has been done—provided the course can be changed sufficiently to open the red light. It will not usually be *necessary* to make so great a change as this, merely to insure passing astern, but it is very desirable to do it if B is not too far on the bow, as it immediately clears up the situation for both ships. The whistle signal required by the new Rules of the Road, for a change of course, is an additional safeguard in this case, which could not be used for a mere reduction of speed. If, however, B is more than three or four points on the bow, it will suffice to slow as much as may be necessary to let her draw ahead, changing course later if it shall seem advisable.

In changing course to avoid collision, port helm is required of A by the article which directs her, whenever possible, to pass astern of B. This is a survival of the old "Law of Port Helm" which has been the object of such violent denunciation from writers on the Rules of the Road. When confined, as it is by the present rules, to the ship having the other on her own starboard hand, this law is perfectly sound; but it was at one time regarded as applying to all ships under almost all circumstances.

2nd, If the vessels are dangerously close when they sight each other, A is relieved from the obligation to pass astern of B, unless it shall appear that this is the safest course that she can take. We shall find that, as a matter of fact, it is in a majority of cases the only course that can give her a hope of safety; and that port helm is usually even more imperatively demanded of her in this case, than when the space available for manœuvring is greater.

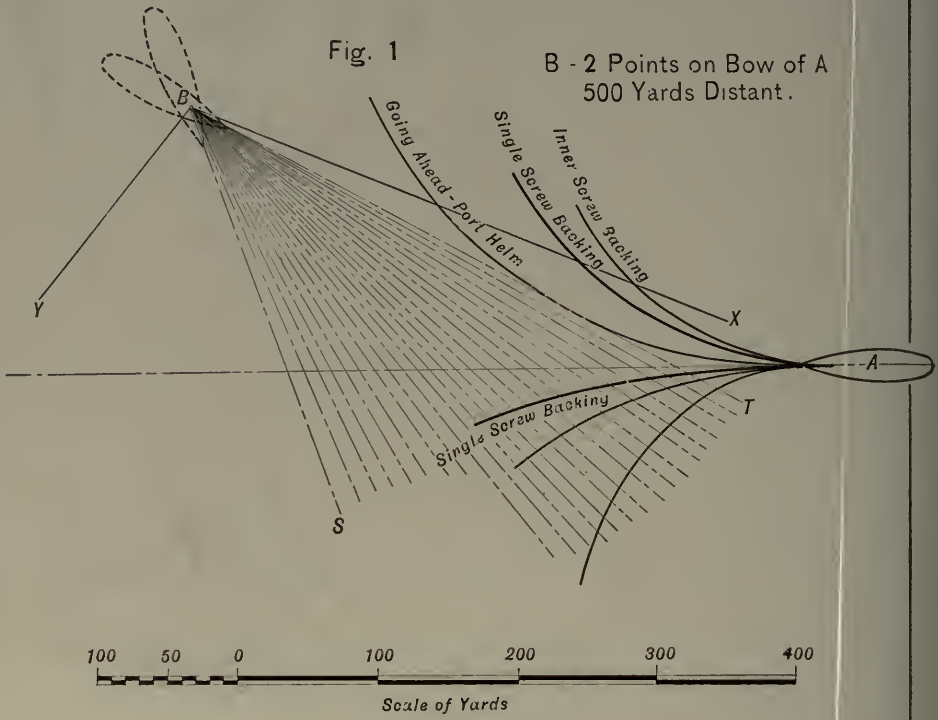
The first impulse of many officers in such a situation is to turn away from the danger, and at the same time to reverse the engines with full power. This course is much more likely to cause collisions than to prevent them. It may be right for B (the holding-on vessel) to turn away, if the emergency is such as to call for any action on her part; but if she does this, so far from reversing her engines, she should, if possible, increase her speed, as her whole effort must be directed to getting across the bow of A as quickly as possible. On the other hand, A should reduce her speed, but should at the same time turn to starboard.

A vessel turning away from another vessel to avoid collision should always continue at full speed, as the effort involved in this course is an attempt to cross the other vessel's bow. To turn away and slow is the surest possible way of bringing about collision.

To make it clear why A turns toward the danger instead of away from it, we may refer to Plates **98** and **99**, where B is placed, in the successive figures, on bearings from two to five points on

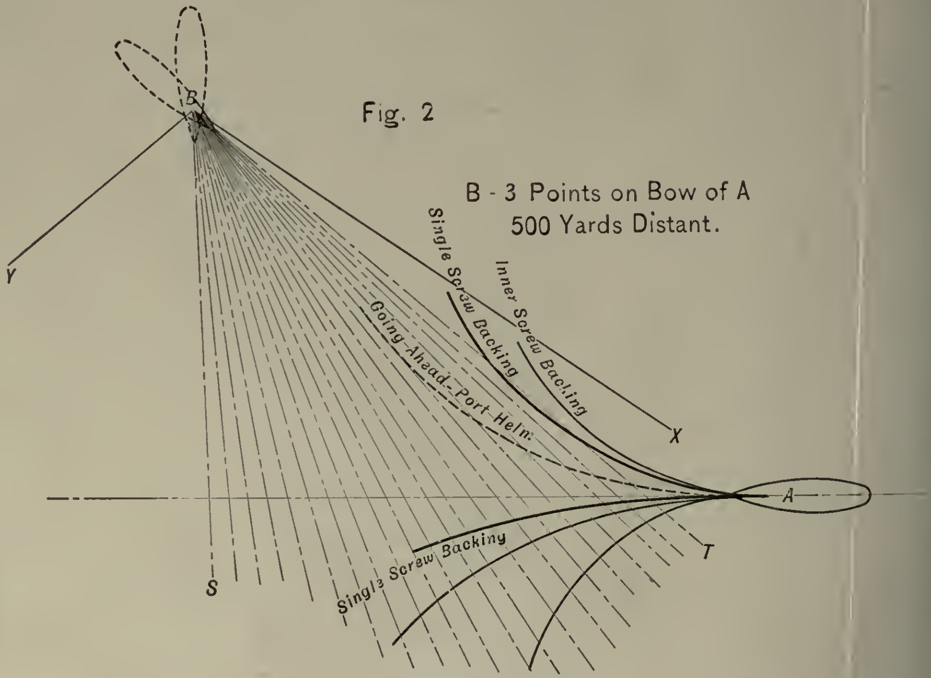
Plate No. 98.

Fig. 1



B - 2 Points on Bow of A
500 Yards Distant.

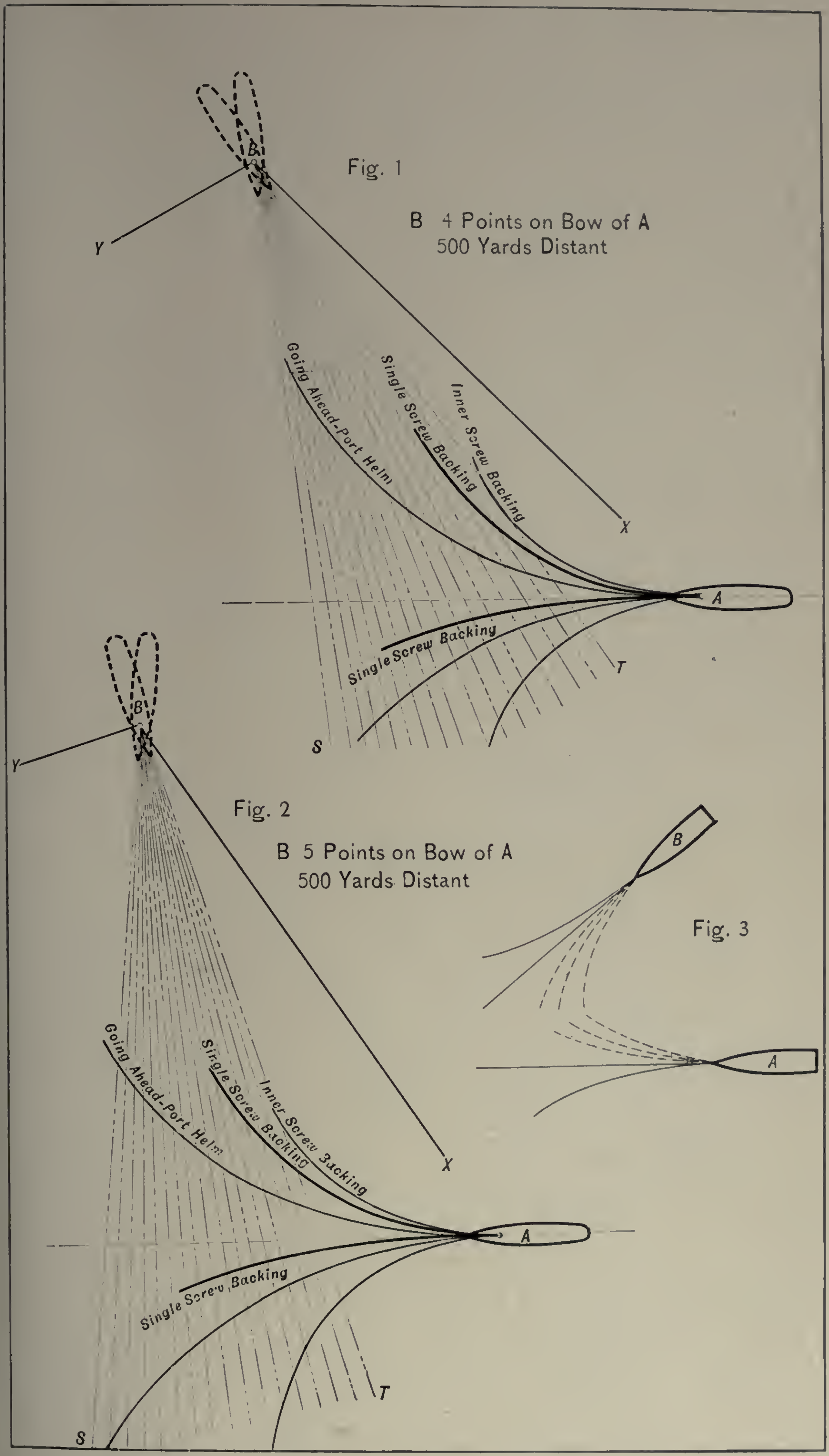
Fig. 2



B - 3 Points on Bow of A
500 Yards Distant.

MANOEUVRING TO AVOID COLLISION.

Plate No. 99.



MANOEUVRING TO AVOID COLLISION.

A's bow, and showing a red light. In such a situation, the action to be taken will not depend upon the exact distance between the ships. This distance is here taken, for convenience of plotting, at 500 yards, but it may be more or less than this without modifying the principle involved, except in one special case to be hereafter considered.

As we cannot suppose that A in this case has time to watch for a change of bearing, or that she will have any information of B's course and speed beyond that given by a red and white light, we must consider that, so far as A's knowledge goes, B may be heading anywhere between the lines BX and BY. If, however, she is heading nearly along BX, she is safe to pass astern of A;[1] and if she is heading well off toward BY, the danger of collision, although it may still exist, will be comparatively remote. The situation will not be one of serious emergency unless B is heading on some course within the sector SBT.

If A turns to starboard and reverses, using helm and engines together to the best advantage, she will follow the heavy line (approximately). If she has twin screws and reverses the inner one, at the same time putting her helm aport, she will follow the light line. In either case, if she does not turn clear of the danger sector, she will cut only a few of its lines (that is to say, only a few of the possible courses of B); and she will at the same time present her stem to B, thus reducing, at once, the danger of collision and the damage to be expected if collision occurs. If she turns to port, she not only cuts every one of the courses of B within the danger sector, but she throws herself across B's path broadside on, inviting the most fatal blow that one ship can give another.

If it be contended that, in placing the ships 500 yards apart, we have taken too great a distance for urgent danger, the answer is that at less than this we approach the case in which collision is not only imminent but almost inevitable and for which no hard and fast rules can be laid down. Whether, in such a case, it is safer to turn toward the danger or away from it will depend largely upon the angle at which the courses converge; and when the vessels are very close together, we may assume that something will be known about this, since it is hardly to be supposed that two vessels within a few hundred yards of each other will not see something besides each others running lights. If it is seen that the courses converge as in Fig. 3, Plate **99**, it is clear that each should turn away from the other.

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[1] It will be noted that A could, by turning with the starboard screw backing, collide with B even if B is heading along BX; but long before this could happen, A would see B's green light and would resume her course.

In the case where A has B nearly on the beam, the importance of turning inward is less marked than when she is on the bow, and it is generally safe to slow or stop to let her draw ahead, or at least to let the situation declare itself clearly.

With regard to B's course when she finds herself called upon under Art. 21 to act for the avoidance of collision with a vessel on her port hand (A), she should, in most cases, turn away, with port helm, and keep her speed or if possible increase it. But this involves presenting her broadside to A; and if the ships are so close that it is evident collision cannot be avoided, there is no question that B should turn inward, presenting her bow as nearly as possible to A, and stopping; remembering, if she has a single (right-handed) screw, that backing will throw her head to starboard and may defeat the object of the manœuvre. This is a situation for which it is impossible to lay down hard and fast rules; and all that is attempted here is to call attention to all the factors in the problem.

If B has twin screws, she should, if she puts her helm to starboard, reverse the inner (port) screw, and follow this up by reversing the other one as soon as she has begun to swing. There is a chance that the ships may still avoid each other, and if they meet, the damage will be less than if either of them strikes the other full on the broadside.

If A (a steamer) meets a sailing-vessel, her obligation to keep clear is the same whether the latter is on her starboard or her port hand. The law requires her, also, whenever the circumstances admit, to give way by passing astern. Where a right-handed screw steamer is to turn to port to avoid collision with a vessel approaching from that side, it is important to remember that if the engines are reversed they will probably destroy the effect of the helm, and throw the head to starboard, thus increasing, rather than diminishing, the danger. The point is of special importance because this situation, if arising at all, is likely to come in the form of an emergency, as the lights of sailing-vessels rarely show at the distance prescribed by law, and frequently cannot be seen until close aboard. With twin-screws it is as easy to turn to one side as to the other.

It will be clear from what has been said in § II, concerning the relation of a fast steamer to a comparatively slow vessel crossing her track, that there is here a strong temptation to turn away from the slower vessel in the hope of getting across her bow; and no doubt there are situations in which this is the only thing to be done; but it is accompanied by serious risk and should be resorted to only in an extreme emergency. If it is attempted, *the speed must be maintained at its maximum.* In the event of turning inward, the rules laid down in § IV of Chapter XIII should be carefully observed; that is to say, in turning to port (for example) the helm should be put hard a-starboard instantly and the engines stopped; then, *after the head has begun to swing decidedly to port*, the engines should be reversed, and, finally, the helm shifted to hard aport. This supposes a right-handed screw.

§ V.

IN A FOG.

An officer hearing the fog-signal of a vessel which he cannot see, can usually form a general idea of its bearing and may be able to judge something of its distance; but even with regard to these points, there is danger of serious error, and of all other points he is absolutely ignorant. The other vessel may be heading toward him, or crossing his course at any angle, or running parallel with him. If, however, he hears her signal more than once, he can judge whether she is drawing nearer or not, and can perhaps tell something of her course; and if she is stopped, her signal will tell him this.

A steamer's whistle can be heard, under favorable circumstances, two miles or more, and rather farther in a fog than in clear weather; but so many things affect the question of audibility that it is not safe to rely upon hearing it more than, say, half a mile, even when all conditions seem to be favorable. The fog-horn of a sailing-vessel can in some cases be heard a mile or more, but in other cases not more than a few hundred yards. The law does not require the signal (of a steamer) to be sounded oftener than once in two minutes, and in this interval, a vessel running 10 knots will cover between 600 and 700 yards, while two vessels approaching each other on a bow bearing will draw together by half a mile.

It can be shown that the safest bearing on which one vessel, A, can have the fog-signal of another vessel, B, is directly ahead. If the signal indicates that B is stopped, she can be easily avoided; and if she is standing across, she will be clear before A can reach her. There is no danger of collision, unless she is heading toward A; that is to say, within the very small angle subtended by A's beam; and in this case the vessels should be able to pass clear, with port helm, after sighting each other. If they meet, it will be either stem to stem or with a glancing blow, and such collisions are never very serious.

Not only is a blow on the broadside far more dangerous than one on the stem, but the length offered by the broadside to possible collision is from eight to ten times as great as in the case of the stem; from which we may argue that, so far as other considerations of law and seamanship permit, any vessel in danger of collision with another should present her stem to the danger, rather than her broadside.

The rules governing the manœuvring of steamers, as laid down in Chapter XIII, are evidently of maximum importance in a fog, as are also the facts in connection with stopping, given in Section VI of this chapter.

Broadly speaking, the Rules of the Road for vessels crossing apply in a fog as well as in clear weather, but a certain time must elapse, after the signals are first heard, before it can be determined whether the vessels are in fact crossing, or passing clear of each other. If they are passing clear, any change of course on the part of either may introduce danger; and no such change will be justifiable unless it can be shown to contribute, on the whole, to the *probability* of safety. In the interval of uncertainty following the first hearing of the signal (forward of the beam), the law requires that both vessels shall stop their engines. It does not require them to reverse, because this would destroy, to a great extent, the control of the ship by the helm.

Starting with this single demand of the law, we have to inquire whether anything else is demanded by seamanship.

Plate No. 100.

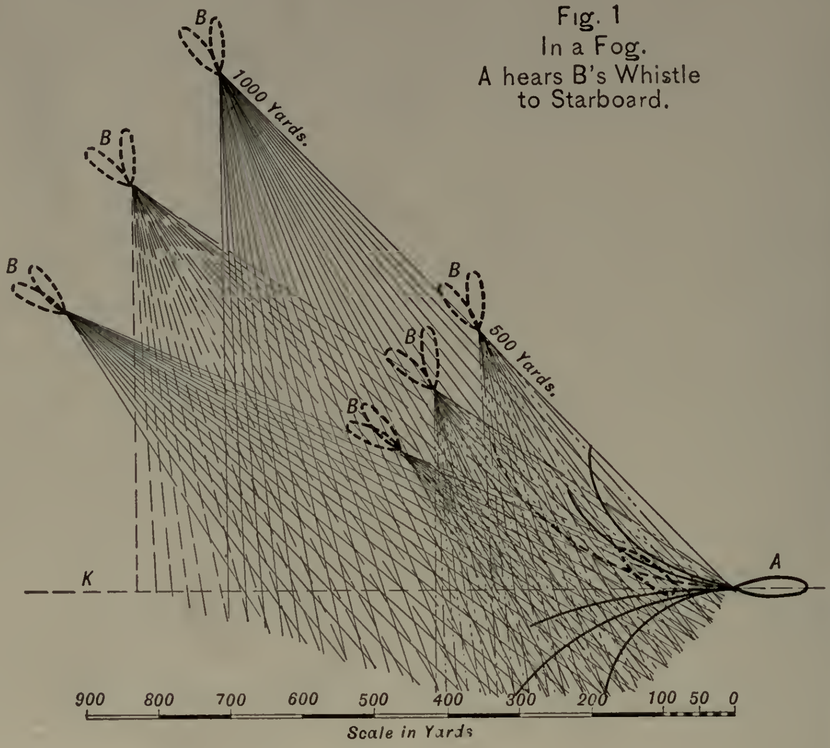

Fig. 1
In a Fog.
A hears B's Whistle
to Starboard.

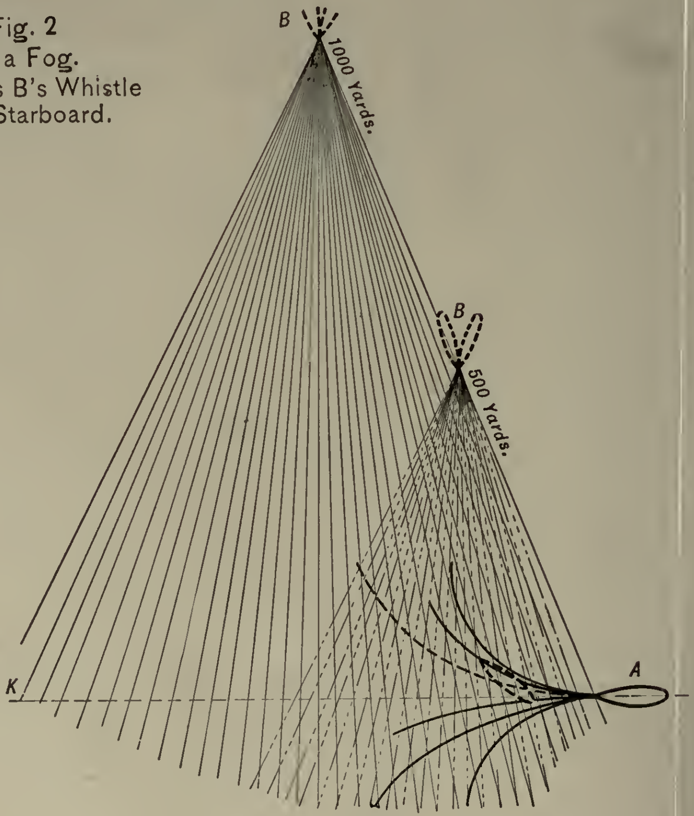

Fig. 2
In a Fog.
A hears B's Whistle
to Starboard.

MANOEUVRING TO AVOID COLLISION

Consider, first, the case of a steamer hearing, *on her starboard bow*, the signal of another steamer, of whose exact bearing she cannot be sure, and of whose distance she knows only that it is not great. A, Plate **100**.

A has no means of knowing whether the vessels are crossing or not, but she knows immediately that, if they are crossing, she must keep out of the way. If she contents herself with stopping her engines, she will range ahead, with constantly diminishing speed, along the line AK. If she turns to either side, she will follow one of the curving tracks.[1] As regards the possible courses of B, we need consider only those which involve a chance of collision. These will all lie within the "danger sector" shown. Clearly, if A turns inward, she cuts comparatively few of these possible courses of B, and at the same time she presents her stem, instead of her broadside, to such danger as may exist. If time and space permit her to turn fully toward B, she will have placed herself in the safest position she could take with reference to another vessel whose course is unknown.

If, on the other hand, A keeps her course or turns away from B, she cuts directly through the danger sector, and exposes her broadside to collision in case it proves that B is heading across.

From the moment when it becomes clear that B is crossing, the Rules of the Road apply to the situation; and these rules require that A shall keep clear and that she shall, if possible, pass astern of B, to do which she must turn inward; that is to say, the manœuvre required of A, *after the ships have drawn dangerously close*, is the same that is suggested by the foregoing considerations for the very beginning, when the time and space available for it are much greater, and while the ship has speed enough to be under satisfactory command.

In view of all these facts, it seems safe to say that a steamer in a fog, hearing the signal of another vessel *on her starboard bow*, should turn toward the signal in the shortest possible space and time, stopping her engines as required by law, and backing if this will assist in turning. She should not continue backing long enough to come to a dead stop unless it is evident that this is called for by the emergency. In other words, it is not well to renounce control by the helm while doubt still exists about the course and position of the other vessel. Having brought the signal ahead, she should hold the compass course thus fixed until it becomes clear what course the other vessel is making.

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[1] The tracks shown are for a vessel 300 feet long, but the conclusions drawn from them will hold for vessels of any length.

If the signal heard is on the starboard hand, but only a little forward of the beam, the advantages of turning immediately toward it are not so marked, although there is high authority for recommending it even in this case. It is probably better for A, after stopping her engines, to hold her course for awhile, bearing in mind, however, that if she finds reason to change her course at all it will be to starboard, and that she should be ready to do this the moment it becomes clear that B is crossing. If, later, she turns to starboard, she will probably have reason to back her engines at the same time.

We have now to consider what B should do upon hearing the signal of A, a steamer, on the *port* hand. Certain of the arguments which have been applied to the preceding case apply with equal force here, and, as far as they go, suggest that B also should turn inward (toward A); but a decisive argument against this is that, if the ships are not crossing, B is not called upon to take any action whatever; and if they are crossing, it is her duty to keep her course, letting A pass astern of her, and directing all her own efforts to getting across A's bow as quickly as possible. She should, therefore, in the period of uncertainty following the first hearing of the signal, hold her course with her engines stopped. The moment that the situation is recognized as one of crossing, she should start her engines ahead, *unless the circumstances make it evident that she cannot get across.* In this case, which can only arise when the ships are very close, she should turn toward A and stop. Whether she should back or not will depend upon the effect this will have on her steering, and upon other circumstances as they reveal themselves at the moment.

An officer on the bridge of a steamer, hearing a sailing-vessel's fog-horn forward of the beam on either side, has several things to help him in deciding whether danger exists and how it can be avoided. The number of blasts heard will tell him on which tack the other vessel is, and the force and true direction of the wind will tell him much about her course and speed. The law requires him to stop his engines, in this as in other cases; and if the vessels seem to be meeting or crossing with danger of collision, it requires him to keep clear, and, if circumstances admit, to avoid crossing the other vessel's bow. As a fog-horn can be heard but a very short distance, it must generally be assumed in this situation that the vessels are dangerously close; and to decide whether "circumstances will admit" of passing astern of the sailing-vessel, calls for rather nice judgment; the more so as the decision must be formed without the least delay. If the steamer is running as slowly as under the law she should be, and with the large reserve of power which, as we have seen, will enable her to stop within her own length, or slightly more than this, she should usually turn toward the signal and reverse her engines (provided danger of collision is found to exist). If no danger exists, the steamer keeps course and resumes speed.

An officer in charge of the deck of a steamer should at all times, but especially at night and in a fog, have as exact a knowledge as possible of the true direction of the wind. This can be told accurately enough from the surface ripples on the water, when these can be seen. At other times, it must be estimated from the apparent direction and force of the wind and from the general direction of the sea, remembering, however, that this does not always run with the wind blowing at the time.

The wind is rarely fresh in a fog, but may blow with any force in falling snow or heavy rainstorm, either one of which is more to be dreaded than a fog.

Exception may be taken to the rules laid down above, on the ground that by turning immediately toward a fog-signal, we run a risk of introducing danger where none would otherwise exist. It should be noted, however, that this action is recommended only for the vessel which, in case there proves to be danger, must keep clear, and *and keep clear by this very manoeuvre;* also, that a vessel turning and backing at the same time, gains very little ground to the right or left of her original course, and finally that, as already noted, the best we can hope to do in a fog is to take the course which gives the greatest *probability* of safety *in view of the evidence available.*

§ VI.

SPEED IN A FOG.

This subject has been treated as a matter of Law, in connection with the Rules of the Road. It will be treated here as a matter of Seamanship.

It has been shown in § III, that a vessel running at very high speed, can, with comparative ease, avoid collision with a slow vessel crossing her path, provided that she makes out this vessel at a fair distance and is sure that it is crossing.

But in a fog, while a signal may be heard at a considerable distance, it can never be located with precision, and there is no means of telling whether the vessel from which it comes is crossing or not. The advantages of high speed are confined to cases in which the crossing vessel is actually seen; and in a fog, a vessel seen is usually so close aboard that a steamer running at full speed would strike her before helm or engines could be touched.

The claim usually put forward by the defenders of high speed is that a steamer handles better at high than at low speed. This is true enough as regards *time*, but altogether false as regards *space*;[1] and in avoiding collision, space, and not time, is the controlling factor. Time enters into the question, it is true, but in another way than this, and a way that is all in favor of low speed. *The great hope of safety in a fog lies in the sound signals prescribed by law.* These are required to be sounded once in two minutes. But in two minutes, a vessel running fifteen knots will pass over half a mile, while two vessels approaching each other, will draw together by a mile.

As there are many conditions of the atmosphere in which signals cannot be heard a mile, it might easily happen that two vessels running at this speed would find themselves in collision without either one having heard the signal of the other. Moreover, a signal once heard gives very little information. It tells of danger, and is a command to stop the engines; but it can rarely be located, even as to the side from which it comes, until it has been repeated once or twice; and even after it is located approximately, there is certain to be some delay in acting.

At five knots, the time available for repetition of the signals, for comprehension of the situation, for decision as to the course called for, and for action upon this decision, is three times as great as at fifteen knots; and it seems hardly necessary to insist that in such an increase of time, there is an enormous increase of safety.

Closely connected with the question of speed in a fog, is that of the space in which a steamer can be stopped under various conditions. This space will depend upon the proportion of her available power which is in use for going ahead. If she is using full power, so that she has no reserve available for backing, it is found that she can be stopped in from three to five times her length; that is to say, the space required is independent of her speed, and directly proportional to her length. Thus a vessel two hundred feet long can be stopped in nine hundred feet, while one six hundred feet long may require nearly three thousand feet.

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[1] See Chapter XIII, § II, where it is shown that the space in which a vessel turns does not greatly vary with her speed.

But a vessel in a fog, running at reduced speed, can have, and should have, a large reserve of power ready for instant use in backing, the only limitation upon this being that "blowing off" shall not be necessary. The greater the proportion which this reserve bears to the power in use for going ahead, the shorter will be the space in which she can be stopped by bringing the reserve into play; and it is evident that, at low speed, a much larger percentage of power can be held in reserve without blowing off, than would be possible at high speed. With such a reserve ready for immediate use, a steamer should be able to stop in two lengths or less; and if she turns while stopping, this distance is still further reduced.

Since both the space in which a ship will stop and that in which she will turn are directly proportional to her length, the importance of running slow and with a large reserve of power is greater in the case of a large steamer than of a small one; yet the largest steamers afloat are the very ones which habitually and openly set the law in this matter at defiance.

A reason frequently given for advocating high speed in a fog is that, the fog belt being of definite width, the danger of collision will be reduced by getting across it as quickly as possible. This is like saying that if one is called upon on a dark night to cross a public square in which people are moving about in all sorts of directions, it will be safer to run across at full speed than to walk slowly. It can easily be shown that in neither of these cases is the probability of collision reduced by reducing the time in which the danger space is crossed.

It is surprising that in none of the discussions which come up from time to time upon the subject of fog-signals, is any suggestion made as to the use of the voice. A good voice can be heard without difficulty a quarter of a mile, and by the use of a megaphone this distance can be more than doubled. It would seem that advantage might often be taken of this fact to establish communication through a fog, and to exchange information as to courses steered, speed, etc.

One of the greatest difficulties in deciding upon a course of action in a fog comes from the impossibility of determining with certainty the direction of sounds. This necessarily reduces the value of all rules which involve the location of signals heard.

There is on the market an instrument designed to overcome this difficulty. Should it prove a success, its value could hardly be overestimated.

It is well known that fogs do not usually extend to any great height, and that they are often thin at, and for some distance above, the surface of the water. They are probably denser at about the height of a steamer's bridge than at any other point. By stationing lookouts as high and as low as possible, dangers may sometimes be made out above or below the fog, long before they can be seen from the deck or the bridge.

It is important to remember that when vessels sight each other through a fog, the signals of Art. 28 of the Rules of the Road become available and must be used if the course is changed or the engines backed. These signals must not be used when the vessels are not in sight of each other, no matter how close they may be.

CHAPTER XVI.

PILOTING.

§ I.

The navigation of a ship at a distance from land, sometimes known as "Proper Piloting" is not a matter of Seamanship. This chapter will therefore deal only with the handling of vessels in coasting and in navigating harbors and other restricted waters by the aid of soundings, buoys, lights, ranges, etc. For safe navigation under these conditions, it is important that the compass error should be accurately known, that reliable soundings should be had at frequent intervals, and that facilities should be provided for taking bearings quickly and plotting them accurately.

The compass error should be determined for the courses that are to be used in coming upon the coast, at the latest possible time. The leadlines should be examined and their marks verified.

Good leadsmen are rare and time and trouble are well spent in training a few of them who can be relied upon when exact results are needed.

The Charts, Sailing Directions, Light and Buoy Lists, etc., should be studied and care taken that they are corrected to date.

It is very desirable that the chart should be habitually kept on the bridge in pilot waters and for this it is convenient not only to have a large board permanently fixed on the bridge, but to use, in addition to this, one or more smaller portable boards to which the charts are tacked and which can be moved about at will. The use of two of these portable boards does away with the necessity of ever handling a loose chart on the bridge, as each chart can be tacked to its board in the chart-house and kept there until wanted. The portable board also does away with the necessity for going to the fixed board whenever it is desired to refer to the chart—a point which may be of great importance in a crowded channel.

For taking bearings, the compass—fitted with a proper azimuth circle—is the most convenient instrument that can be used. When it is not available, the pelorus is substituted for it. (See chapter on "Compass, Log and Lead.")

Sextant angles are sometimes to be preferred to compass bearings, but are not as universally available. They are unquestionably more reliable than compass bearings where everything is favorable for their use, if only because they involve no such uncertain element as deviation; but they require three conspicuous and accurately charted objects separated by favorable angles; and these conditions are not very often to be found. All officers should, however, be familiar with the use of the sextant for measuring horizontal angles and of the three-arm protractor for plotting them.[1]

Another convenient and valuable use of the sextant in piloting is for determining distances by the vertical angles subended by light-houses, etc., the heights of which are known.

Tables are published which give at a glance the distance of an object of a certain height corresponding to any observed sextant angle; but in the absence of such a table, it is not difficult to make the necessary calculation. A common application of this principle is the "vertical danger-angle." Having to pass a light-house or some similar object of known height, we decide at what minimum distance it shall be passed, determine the angle which it will subtend at that distance, and then, by frequent observation, make certain that the angle is not allowed to exceed this value.

Strictly speaking, the height of the observer's eye is a factor in this problem, but for ordinary purposes this may be disregarded.

Evidently the same angle enables us to keep at a safe distance *inside* of an outlying danger if we have to pass between it and the coast; and we may even work our way between two dangers in this manner.

The "Horizontal Danger-Angle" is used where there are two well-defined objects in the vicinity of a hidden danger. In Fig. 1, Plate **101**, suppose A and B to represent two prominent objects which are plotted on the chart, and C an outlying danger. At a safe distance to seaward of C, place a mark D, and draw a circle through A, B and D. Draw also the lines A D and B D and with a protractor measure the angle A D B. This angle is the "danger-angle." So long as the angle between A and B measured at the ship is less than A D B, the ship is outside the circle shown. If the angle becomes greater than A D B, she is within the circle. When it is equal to A D B, she is on the circle.

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[1] See the Chapter in Lecky's Wrinkles in Practical Navigation, on "The Station Pointer"—this being the English name for the three-arm protractor.

It is a well-known geometrical proposition that "all the angles inscribed in the same segment of a circle are equal." In other words, all the angles that can be formed by lines drawn from points in the circumference to the extremities of the chord A B will be equal to each other. As we pass inside the circle, the angles will increase; as we pass outside they will decrease.

In running along the land with prominent marks in sight, the position should be plotted frequently, as there is always danger that the ship will be set in by a current of which the chart and Sailing Directions give no hint. If two well-marked points are in sight, so placed that their lines of bearing "cut" at a favorable angle, the simplest method of fixing the position is by cross-bearings. If only one suitable object can be seen, its line of bearing may be plotted and an attempt made to fix the position of the ship on this line by an estimate of distance, by a sounding or by some other means. If the object seen chances to be a light just coming above the horizon (a common situation), its distance may be determined with considerable accuracy from its height and that of the observer's eye. It happens that the distance from any given height to the visible sea-horizon is, in miles, approximately equal to the square root of the height in feet. Thus, if an observer whose eye is 25 feet above the water-line, sees, *just on the horizon*, a light whose height he knows to be 100 feet, he will not be far wrong in assuming its distance as 15 miles.

For more exact results, the following table is convenient:

TABLE OF DISTANCES AT WHICH OBJECTS CAN BE SEEN AT SEA, ACCORDING TO THEIR RESPECTIVE ELEVATIONS AND THE ELEVATION OF THE EYE OF THE OBSERVER.

Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.
5	2·565	70	9·598	250	18·14
10	3·628	75	9·935	300	19·87
15	4·443	80	10·26	350	21·46
20	5·130	85	10·57	400	22·94
25	5·736	90	10·88	450	24·33
30	6·283	95	11·18	500	25·65
35	6·787	100	11·47	550	26·90
40	7·255	110	12·03	600	28·10
45	7·696	120	12·56	650	29·25
50	8·112	130	13 08	700	30·28
55	8·509	140	13·57	800	32·45
60	8·886	150	14·22	900	34·54
65	9·249	200	16·22	1000	36·28

Example.—A tower, 200 feet high, will be visible to an observer whose eye is elevated 15 feet above the water, 21 nautical miles nearly: thus from the table:

15 feet elevation, distance visible 4·44 nautical miles.
200 " " 16·22 "
20·66

Abnormal refraction may introduce an error here. And on a coast where the rise and fall of the tide are excessive, neglect to allow for this might be a serious matter.

If the light is *above* the horizon, the observer may move downward until he finds the height that brings it to the water-line.

Two observations of a single object will give a "fix," if the course and distance run in the elapsed time are noted. In running on a steady course with such an object in sight we have a series of simple triangles formed by the intersection of the course with the successive lines of bearing (Fig. 2, Plate 101). In these triangles, we have given the side RS, representing the distance run between any two bearings, and the angles made by these bearings with the course; ART and AST. The triangles might, of course, be solved simply enough by ordinary mathematical processes, but these are not suited for work on the bridge. The table which follows gives the solution without calculation. It is a good plan to have a copy of this posted on a board and hung in the chart-house.

TO FIND THE DISTANCE OF AN OBJECT BY TWO BEARINGS, KNOWING THE DISTANCE RUN BETWEEN THEM.

Rule.—Under the number of points contained between the course and second bearing, and opposite to the difference between the course and first bearing, will be found a number which multiplied by the miles made good will give the distance of the object (in miles) at the time the last bearing was taken.

N. B.—Due allowance should be made for current.

Difference between the Course and Second Bearing in Points of the Compass.

4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	12½	Pts.
1·00	0·81	0·69	0·60	0·54	0·49	0·46	0·43	0·41	0·40	0·39	0·38	0·38	0·38	0·39	0·40	0·41	0·43	2
	1·23	1·00	0·85	0·74	0·67	0·61	0·57	0·53	0·51	0·49	0·48	0·47	0·47	0·47	0·48	0·49	0·51	2½
		1·45	1·17	1·00	0.88	0·79	0·72	0·67	0·63	0·60	0·58	0·57	0·56	0·56	0·56	0·57	0·58	3
			1·66	1·35	1.14	1·00	0·90	0·82	0·76	0·72	0·69	0·66	0·65	0·64	0·64	0·64	0·65	3½
				1·85	1·50	1·27	1·11	1·00	0·92	0·15	0·80	0·76	0·74	0·72	0·71	0·71	0·71	4
					2·02	1·64	1·39	1·22	1·09	1·00	0·93	0·88	0·84	0·81	0·79	0·78	0·78	4½
						2·17	1·77	1·50	1·31	1·18	1·08	1·00	0·94	0·90	0·87	0·85	0·83	5
							2.30	1·87	1·58	1·39	1·25	1·14	1·06	1·00	0·95	0·92	0·90	5½
								2·41	1·96	1·66	1·46	1·31	1·19	1·11	1·05	1·00	0·97	6
									2·50	2·03	1·72	1·51	1·35	1·24	1·15	1·08	1·03	6½
										2.56	2·08	1·76	1·55	1·39	1·27	1·18	1·11	7
											2·60	2·11	1·79	1·57	1·41	1·29	1·20	7½
												2·61	2·12	1·80	1·58	1·41	1·29	8
													2·60	2·11	1·79	1·57	1·41	8½
														2·56	2·08	1·76	1·55	9
															2·50	2·03	1·72	9½
																2·41	1·96	10
																	2·30	10½

Difference between the Course and First Bearing in points of the Compass.

Example.—A lighthouse bore WNW. The ship ran 6 knots, West, and the lighthouse then bore NW. ½N. Required the distance of the lighthouse at the time of the second bearing.

Angle between the course and first bearing = 2 points.
" " " " " second " = 4½ "
Multiplier from table = 0·81
Distance = 6 × 0·81 = 4·86 nautical miles.

In the absence of a table, the problem may be solved graphically by plotting the lines of bearing on the chart and determining by the aid of rulers and dividers where the *given course* must cut these lines to make the distance between them equal the run of the ship (Fig. 3, Plate **101**).

There are several convenient applications of the above-described principles to practical cases, which call for neither a Table nor a Chart. If the second observation is taken when the angle between the line of bearing and the course (A S T) is exactly double what it was at the time of the first observation

(A R T), the distance of the ship from the object at the time of the second observation is equal to the run of the ship between the observations.

Again, knowing the distance A S, and the angle A S T, we may by reference to the Traverse Table, determine the distance at which the point A will be when abeam.

It will be understood that in all observations involving the run of the ship, allowance must be made for any current that may be known to exist.

If the first bearing is taken when the point A is exactly on the bow and the second when it is abeam, the distance at the time of the second observation will be equal to the run of the ship between observations. This method of fixing the distance from an object when abeam is called the method of "Bow and Beam Bearings" and is usually carried out with all prominent landmarks passed. There is no reason why both this method and the preceding one should not be made matters of routine and all observations connected with them entered in a "Coasting Record" to be kept in the chart-house.

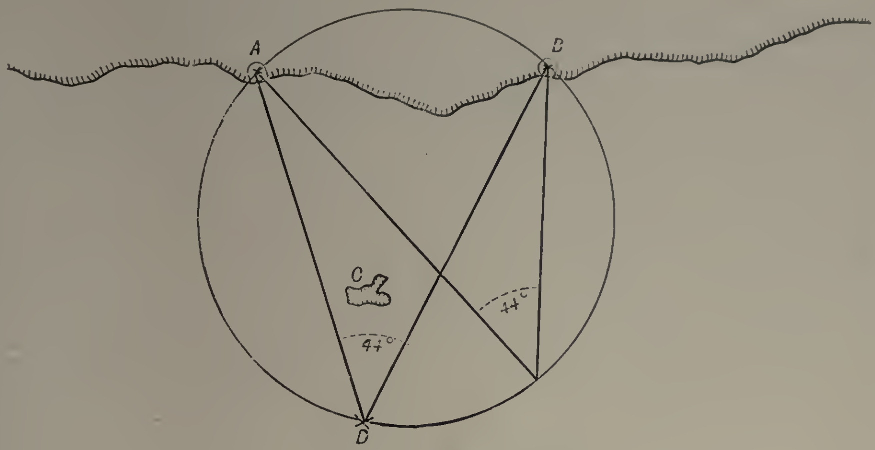
In this connection, attention may be called to the importance of recording all observations accurately at the time they are made, and of noting the reading of the patent log for every observation that has to do with the navigation of the ship, whether this be a sight, a sounding or a bearing.

Advantage should be taken of every opportunity for getting a line of position by means of two objects "in range" with each other. This calls for no measuring of bearings and is at once the most convenient and the most accurate line that can be obtained. If, at the instant that the range is closed, a bearing of another object be noted, or the sextant angle measured between another object and the range, the position is fixed at once.

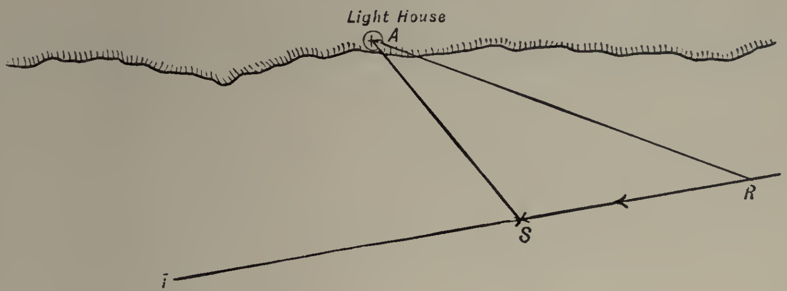
A convenient way of determining the compass-error is to take the bearing of a well-defined and accurately charted range.

As a general rule, where coasts are well charted, well lighted and well buoyed, the safest way to navigate them is to keep close enough to see and clearly identify the landmarks in regular succession, running from one mark to another with careful bearings on them all, taking advantage of every opportunity

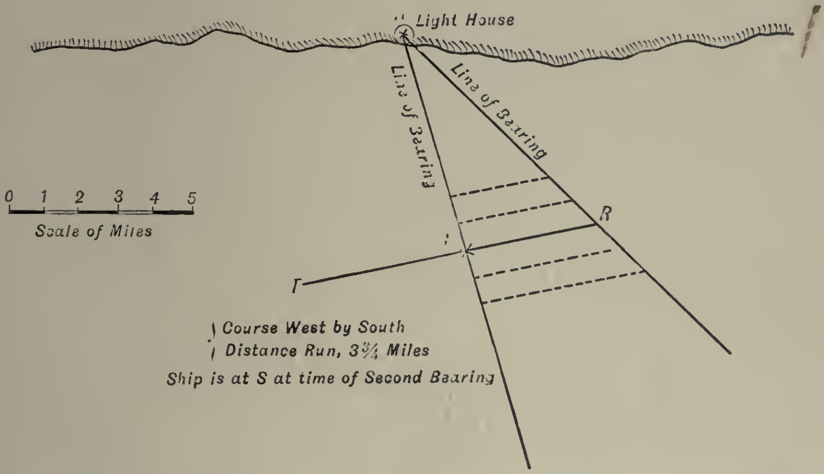
Plate No. 101.



Horizontal Danger Angle.
Fig. 1



Determining the Position by Two Bearings with the Run between.
Fig. 2



Course West by South
Distance Run, 3¾ Miles
Ship is at S at time of Second Bearing

Fixing the Position Graphically by Two Bearings with the Run between.
Fig. 3

DETERMINING POSITION IN COASTING.

to fix the position, and watching especially to see if the ship is being set in toward danger as she often will be by currents which, in many cases, there is no reason to anticipate. In this way, the position is always known within a few miles and it is much safer than to keep off so far that marks cannot be seen, until the time when it becomes necessary to close with the coast; for when this time comes, you may be far out of your reckoning and a little mistake in standing in may have serious results. Another reason for keeping hold of the marks is that if the weather becomes thick, you know your position with certainty up to the last moment and so have a "departure" upon which you can rely for running in the fog. It is needless to say that in a fog, dangers should be given a wider berth than in clear weather, but even in a fog it is safer to feel the way along by careful soundings and by the help of the sound signals provided for the purpose than to cut adrift from everything. (See Section III of this Chapter.)

On coasts which are not well surveyed, no chances should be taken.

It must be remembered that buoys are often out of place and that light vessels may be so; and every effort should be made to fix the position by means of permanent landmarks. Even when buoys, etc., are changed intentionally and with due notice, it may happen that the notice is not received. A vessel approaching New York some years ago at the end of a passage from the Pacific went aground in thick weather because Sandy Hook light-vessel had been moved (three months before) and notice of the change had not been received.

In approaching a harbor, it is important to know not only the state of the tide as to height, but the direction and force of the tidal currents that may be expected. (See Section II.) After the channel is actually entered, the direction of the current may be known from its effect upon buoys and upon vessels at anchor, and all indications of this kind should be carefully noted. It will rarely happen that the currents run perfectly true to the direction of the channel; and where they draw across, the ship will be set over to one side unless a proper allowance is made by heading a little higher than the course that is to be made. In cases of this kind it is very helpful to use a *range;* and if none is laid down on the chart an effort should be made to pick one out ahead. The objects seen need not be recognized to be of use for this.

The line on which the ship is running should be laid down on the chart and the position plotted frequently by such means as are available. This will give warning if she sags to either side.

A ship handles better with the tide against her than when running with it. If obliged to come in with a fair tide, the speed should be kept as high as circumstances permit, to insure good control by the helm.

In approaching a strange harbor, there may be difficulty in recognizing the landmarks and aids to navigation as laid down on the chart. Under such circumstances the ship should be stopped, and if necessary anchored, until the situation is made out clearly. If in doubt about the reliability of surveys, or if the channel is not buoyed, it is well to send a boat ahead to sound it out and mark it temporarily. In running among coral reefs, danger may be made out from aloft at a considerable distance, and intricate passages may be threaded in this way in perfect safety, *provided the sun is at the back of the observer.*

On a coast where careful soundings have been made and charted, the sounding machine gives a valuable means of locating the position. This will be described in another section upon "Navigating in a Fog."

§ II. CURRENTS.

Perhaps the most serious danger connected with piloting is that arising from currents, the force and direction of which are not known. This danger is greater in a fog than under other circumstances, but is one that should be kept in mind at all times when navigating in the neighborhood of dangers.

In most cases there is no way of foretelling with certainty the direction and force of the current to be anticipated at a given place and time, but this ought not to be true of such currents as are *tidal* in their nature. These are closely connected with high and low water; but whereas very elaborate tables are published giving the time of high and low for all parts of the world, there is so little information published with regard to tidal currents that many of the people to whom such information would be of value, remain, after years of sea-faring, under the impression that "slack" water corresponds to "high" and "low," that a falling tide is necessarily accompanied by a current running out, and a rising tide by one running in.

This is so far from being true that at many places high and low water correspond with the maximum strength of tidal current. This commonly occurs where a large basin is to be filled through a relatively narrow mouth, as in the case of Chesapeake Bay, and where a narrow body of water lies open to the sea at both ends, as in the English Channel.

> "We must take care not to confound the time of the *turn of the tide stream* with the time of high water. Mistakes and errors have often been produced in tide observations by supposing that the turn of the tide stream is the time of high water. But this is not so. The turn of the stream generally takes place at a different time from high water, except at the head of a bay or creek. The stream of flood commonly runs for some time, often for hours, after the time of high water. In the same way, the stream of ebb runs for some time after low water.
>
> "The time at which the stream turns is often different at different distances from the shore; but the time of high water is not necessarily different at these points.
>
> "In the center of all open channels when the tide runs right through, the streams nearly invariably overrun the times of high and low water by about three hours. In such a locality the stream due to the flood will commence three hours before high water and continue to run for three hours after high water, in the same direction.
>
> "In tidal rivers a modified form of the same phenomenon occurs, *i. e.*, the stream runs up for some time after the water has begun to fall, and runs down after the water has begun to rise." Whewell, "Treatise on Tides."

It is only on an open coast line or in a shallow basin that slack water corresponds with high and low.

In a basin like Chesapeake Bay, the wave of high water travels up until it reaches and is reflected back from the head of the bay. There results from this a rather complicated condition of affairs in the bay, with two points of high and two of low, water, with points of slack midway between the adjoining high and low.

In a place like the English Channel, which lies open to the tides at both ends, the currents flow from both sides toward and away from a certain point, which in the case of the English Channel is near Dover. In this case, moreover, *the tide turns throughout the whole length of the channel at practically the same moment.* Similar phenomena occur in Long Island Sound and East River, which constitute together a single body of water open to the tide at both ends. Here the tidal currents meet and separate at Throg's Neck. It is slack water at practically the same time along nearly the whole length of the Sound, and the same is true of East River, where it is slack at, approximately, one hour and twenty minutes after high and low at Governor's Island.

Local conditions may greatly modify the rules as laid down above. The currents are always weaker near shore than in the middle of the channel, and often run in the opposite direction, sometimes with considerable force. A striking illustration of this is to be seen in Wallabout Bay, an offset from the East River (New York harbor) on which the New York Navy Yard has its water front. At the strength of the flood tide, when the current in the River is running up (to the northeast) with a velocity of several knots an hour, a strong counter current runs along the face of the "Cob-dock" at the Navy Yard. Between the two currents an eddy is formed, which, as the currents slack, flattens out, growing longer and narrower, and finally disappearing as slack water is approached. There is no corresponding phenomenon while the ebb current is running, although the contour of the River results in some puzzling irregularities in the direction of the current.

Tidal currents do not always run in and out along the same line, but in many places swing through a complete circle, running, at different stages of the tide, from every point of the compass. This is well illustrated at Charleston Entrance, South Carolina. Here the first of the flood runs to the southwest, the middle of the flood to west, and so on until it has worked around to a little east of north, at which point the flood ends. A little later the ebb current begins, running to northeast, turns to east by the middle of the ebb, and so works around to south, where it ends.

§ III. NAVIGATING IN A FOG.

The phase of this subject which has to do with the avoidance of collision is fully discussed in Chapter "Manœuvring to Avoid Collision," where it is shown that the law requiring ships to run at "moderate" speed is perfectly reasonable as a matter of seamanship, and that a ship running at such speed, and having, as she should have, a reserve of power for backing hard, can be

Plate No. 102.

Fig. 1

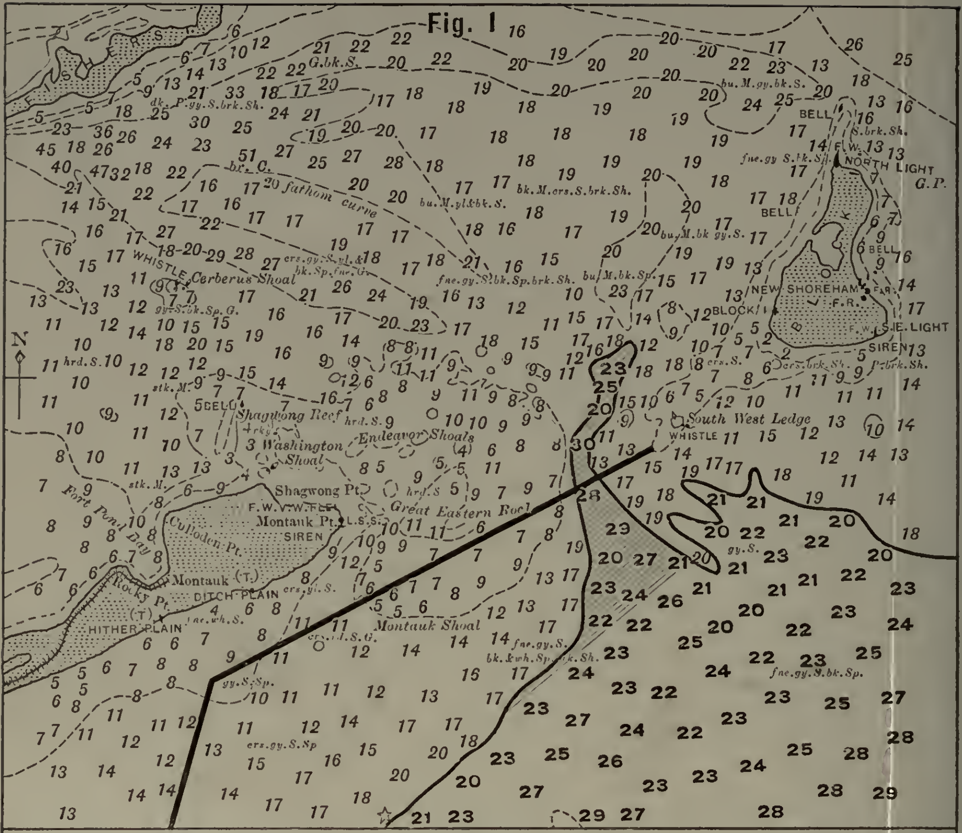
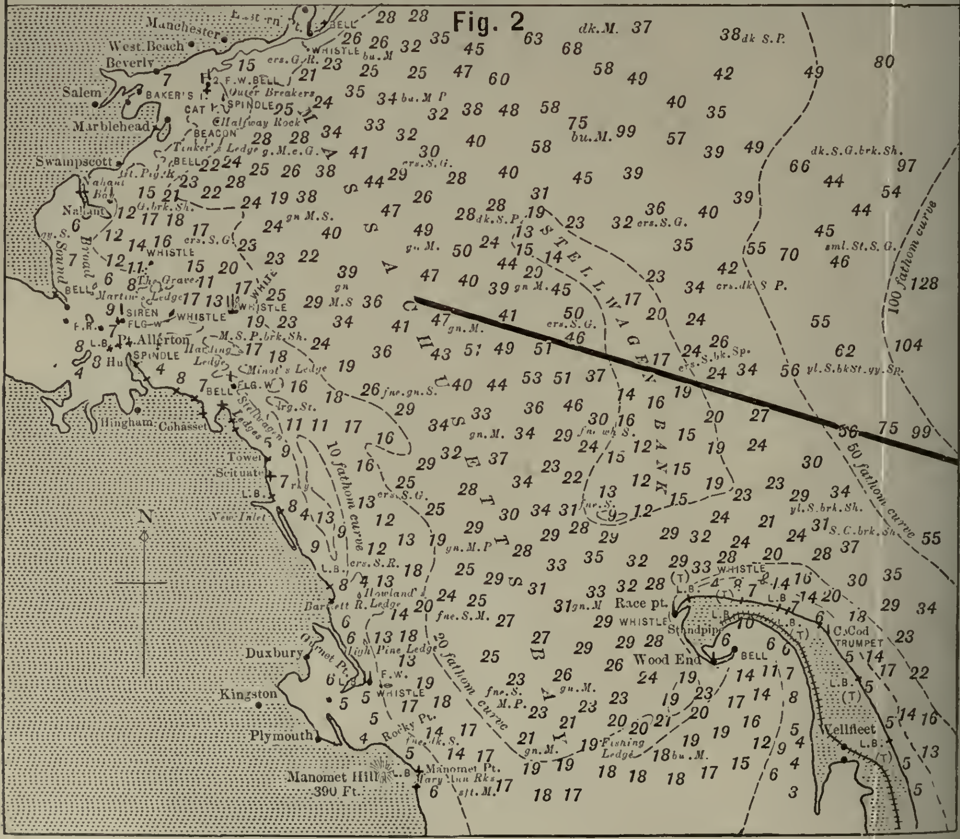


Fig. 2



SIGNIFICANT SOUNDINGS, FIXING POSITION IN A FOG.

stopped in from one to three times her length. It is clear that the same considerations which make this reasonable for the avoidance of collision make it equally so for the avoidance of stranding; but there is another point to be considered here, which is that the effect of currents in throwing the ship out of her reckoning will be greater at a low than at a high speed, their effect varying, in fact, inversely with the speed. This should always be taken into consideration and may under some circumstances constitute a reason for running at higher speed than would otherwise be justifiable.

Experiments with fog-signals have proved that such signals are often inaudible at distances much within that at which they should be heard; and furthermore that a signal which has been heard at a certain distance may be lost *as it is approached*, there being, apparently "zones of silence" surrounding the signals, in which the waves of sound are deflected upward. This has been shown to be a matter of sufficient practical importance to be a source of real danger.

With an exact knowledge of the errors of the patent log and the compass, the dangers of fog are greatly reduced, but the most important element of safety is the modern sounding machine described in Chapter VIII. This machine is used without reduction in the speed of the ship and gives results which are almost absolutely accurate. If the soundings are taken frequently and plotted on a piece of tracing cloth, with the courses and distances between, the position of the ship may often be fixed with surprising accuracy by moving this tracing over the chart until a position is found where the soundings as plotted fall in with the depths given on the chart. It is convenient to draw a number of meridian lines on the tracing-cloth as an assistance in laying off the courses and in keeping these true to the chart while moving the tracing about. The lead is "armed" for each sounding and the sample of bottom brought up should be recorded as carefully as the depth, and given equal weight in locating the position.

It will be understood, of course, that this method of navigating is available only on coasts that have been thoroughly surveyed and accurately charted.

An examination of the chart will often reveal an exceptional formation of the bottom which may be as characteristic as a conspicuous peak or other peculiar formation on land, and as conclusive in establishing a position. Two important illustrations of this are shown in Plate **102**. Fig. 1 shows the soundings at the eastern entrance of Long Island Sound. Here a long, narrow "deep" makes up at right angles to the line connecting Montauk with the southern end of Block Island.

A vessel standing in here in a fog and in doubt about her exact position, could run slowly to the eastward in 7 and 8 fathoms, getting soundings in quick succession. If the soundings increased suddenly from 7 fathoms to 25 or 30, and immediately afterwards decreased almost as suddenly, the position would be fixed as if the fog had lifted and shown the land. Similarly, a vessel standing in for Boston and getting soundings on Stellwagen Bank, would have almost a perfect fix (Fig. 2).

It often becomes necessary in a fog or in weather too thick for sights, to run along a coast or to round a bend, keeping at a certain distance from land. Where the soundings run with some degree of regularity, as for example, along the Atlantic coast of the United States, a certain depth of water (or two limiting depths) may be selected from the chart and the ship kept approximately on the curve of this depth by heading out or in a little as the soundings are found to decrease or to increase. Thus a steamer having to run in thick weather from Boston to Key West could round Nantucket shoals in depths from 28 to 35 fathoms, then striking across to the 20-fathom curve on the coast of New Jersey could follow this curve with safety to Cape Canaverel.

In running a channel where the water shoals gradually on each side, the ship may be kept in the channel by zig-zagging slightly from side to side, the course being changed whenever the water is found shoaling dangerously. The advantage of running more or less across rather than attempting to follow the channel directly is that when the water begins to shoal, we know in which direction the course must be changed to deepen it, whereas if we attempt to follow the channel, and find ourselves in shallow water, we have no means of telling on which side the channel lies.

When in the neighborhood of high land, use can sometimes be made of *echoes* to determine roughly the distance of the land and whether the ship is opposite a bluff or a break in the contour of the coast.

§ IV. BUOYAGE.

The International Marine Conference of 1889 suggested a uniform system of buoyage based first upon color and secondarily upon shape. The following extract from the report of the committee having this subject in charge, puts very clearly the principles which should be included in such a system. These principles have been to a considerable extent adopted by the leading commercial nations of the world, as will be seen in the appended Notes on Buoyage.

Extract from Report of Committee on Buoyage:

"The term starboard hand shall denote that side of a navigable channel which is on the right hand of the mariner entering from seaward; the term port hand shall denote that side which is on the left hand under the same circumstances.

Color.—Buoys defining the starboard hand shall be painted a single red color.

Buoys defining the port hand shall be painted a single black color, or a parti-color.

Buoys defining middle grounds shall be painted with horizontal bands.

Form.—Wherever form is used as a distinctive character.

Buoys defining the starboard hand shall be conical, and those defining the port hand shall be can or spar.

Top Marks.—Countries where form is not used as distinctive character for buoys may adopt as another distinctive feature for the buoys on either side of a channel, top marks resembling a cone to be used on the starboard side, or a cylinder on the port side of a channel.

Numbers and Letters.—Numbers, letters and names may be painted on the buoys, but they must never be so large as to interfere with their distinctive coloring.

Whenever numbers and letters are used they shall be in consecutive order, commencing from seaward.

Buoying and marking of wrecks.—(a) All buoys and the top sides of vessels used for the marking of wrecks, shall be painted green with a suitable white inscription.

(b) Where it is practicable, by day one ball shall be exhibited on the side of the vessel nearest the wreck, and two placed vertically on the other side; three fixed white lights similarly arranged but not the ordinary riding lights, shall be shown from sunset to sunrise."

It should be observed that the above are recommendations and not laws. As a matter of fact, however, the general features of these recommendations have been adopted by most of the Governments which have established uniform and consistent systems of buoyage.

Certain exceptions and additions to this rule are noted below.

1. In the German system, *conical* buoys painted black, mark the starboard side of the channel in entering, and spar or *can* buoys painted red, mark the port side.

2. In Norway, Sweden and Russia a "compass" system of marking is adopted; that is to say, the colors, shapes and topmarks are arranged to indicate the north, south, east and west sides of channels and shoals.

3. Quarantine buoys are invariably yellow.

In Germany, buoys marking target, mine or torpedo grounds are barrel buoys, yellow, carrying small red flags.

4. Buoys defining the limits of anchorages are usually white. But Belgium, Norway, Sweden, Russia and Denmark use white buoys as regular navigational marks.

5. In all countries, special types of buoys, beacons, etc., are used in special places and shown on charts. Such are Bell-buoys, Whistling-buoys, Gas-buoys, Electric-buoys, etc.

6. In regular systems, starboard hand buoys, if numbered, have even numbers, port hand buoys, odd numbers, counting in succession from seaward.

7. The positions and character of buoys should be given on all charts and in all sailing directions, and the latest authoritative information available should always be consulted before entering or leaving a port or coming on a coast.

The following are the rules for the buoyage of the coasts and harbors of the United States:

The buoys used for marking channels, dangers, etc., are called nun, can, ice and spar buoys. With the exception of the spar buoy, which is made of wood, they are constructed of sheet iron with water-tight compartments so that an accidental puncture will not sink them.

In conformity with section 4678 of the Revised Statutes of the United States, the following order is observed in coloring and numbering the buoys along the coasts, or in bays, harbors, sounds, or channels, viz.:

1. In approaching the channel, etc., from seaward, red buoys, with even numbers, will be found on the starboard side of the channel, and must be left on the starboard hand in passing in.

2. In approaching the channel, etc., from seaward, black

buoys, with odd numbers, will be found on the port side of the channel, and must be left on the port hand in passing in.

3. Buoys painted with red and black horizontal stripes will be found on obstructions, with channel ways on either side of them, and may be left on either hand in passing in.

4. Buoys painted white and black perpendicular stripes, will be found in mid-channel, and must be passed close-to to avoid danger.

All other distinguishing marks to buoys will be in addition to the foregoing, and may be employed to mark particular spots, a description of which will be given in the printed list of buoys.

Perches, with balls, cages, etc., will, when placed on buoys, be at turning points, the color and number indicating on which side they shall be passed.

Different channels in the same bay, sound, river, or harbor, will be marked, as far as practicable, by different descriptions of buoys. Principal channels will be marked by nun buoys; secondary channels by can buoys, and minor channels by spar buoys. When there is but one channel, nun buoys, properly colored and numbered, are usually placed on the starboard side, and can buoys on the port side of it.

Day beacons, stakes and spindles (except such as are on the sides of channels, which will be colored like buoys) are constructed and distinguished with special reference to each locality, and particularly in regard to the background upon which they are projected.

Wherever practicable, the towers, beacons, buoys, spindles, and all other aids to navigation are arranged in the buoy list of the Lighthouse Board in regular order as they are passed by vessels entering from sea.

The navigator should keep in mind that the buoys in thoroughfares and passages between the islands along the coast of Maine are numbered and colored for entering from the eastward.

CHAPTER XVII.

HANDLING A STEAMER ALONGSIDE A DOCK.

§ I. PRELIMINARY.

It is clear that the conditions under which work of this kind is to be done may vary almost indefinitely and that the methods used must be varied correspondingly. It would be hopeless to attempt to illustrate all or even any considerable number of the situations which arise in practice, but it is not so difficult to analyze in a general way the various factors involved, and to show their application to a few special cases.

The factors are: lines, helm, screw, headway or sternway of the ship, current, wind.

We begin by considering the use of lines, first alone, then in combination with other factors.

CASE I.

If the ship is lying dead in the water abreast of a dock, as in Fig. 1, Plate **103**, with a bow line leading to the dock, hauling on this line will turn the bow in, of course, but it will also throw the stern out, the ship pivoting about the center of gravity. It should be noted, however, that the stern does not go out quite as much as the bow comes in; for, since the ship is not held rigidly at the pivoting point, the mass as a whole will respond more or less to the force acting on the bow, and the resultant motion will be like that shown in the figure.

If the stern is held by a line to the dock, as in Fig. 2, Plate **103**, the pivot is transferred to the stern and the whole length of the ship comes in as shown. This requires much greater effort than to turn the ship about her natural pivoting point as in Fig. 1.

If the bow and stern lines are hauled on at the same time, the ship may be breasted in bodily, but at an even greater expenditure of work than in the preceding case.

If either of the lines described above leads off at an angle from the beam, it constitutes a "spring," which may be defined as a line diagonal to the keel and exerting a force, when power is

Plate No. 103.

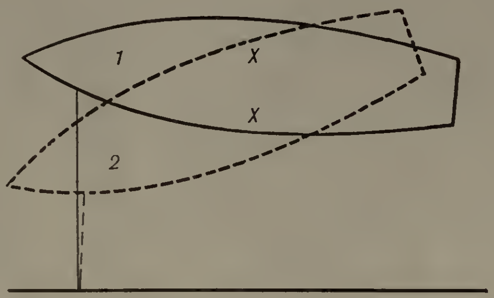


Fig. 1

Fig. 2

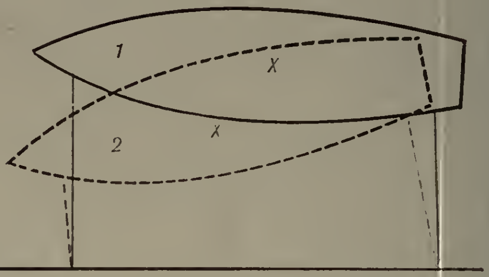


Fig. 3

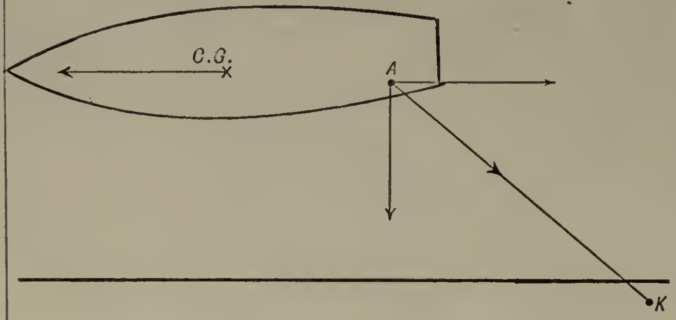
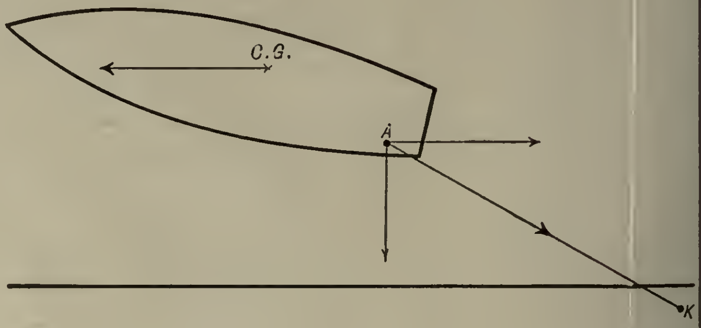


Fig. 4



HANDLING STEAMERS AROUND A DOCK.

Plate No. 104.

Fig. 1

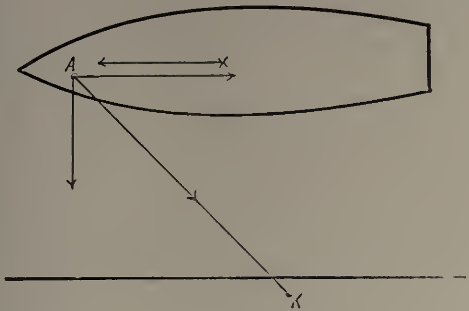


Fig. 2

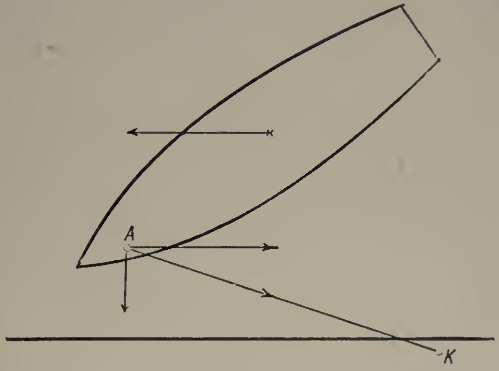


Fig. 3

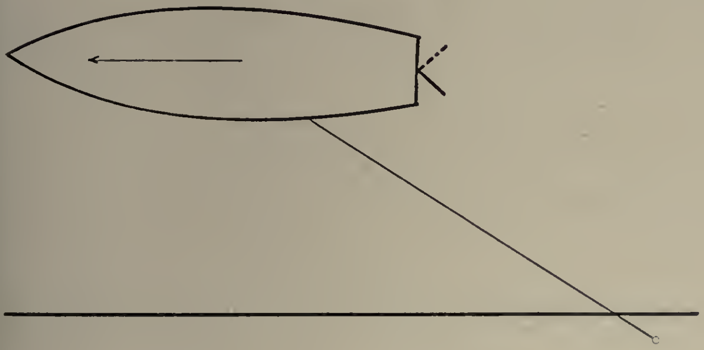
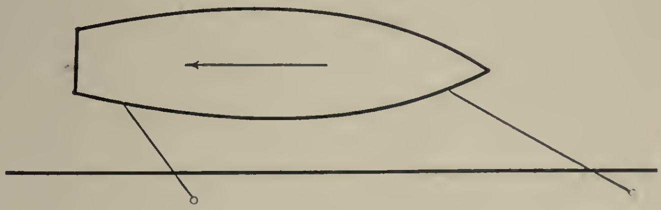


Fig. 4



HANDLING STEAMERS AROUND A DOCK.

applied to it, both in the direction of the keel and at right angles to that direction.

A spring is used, therefore, for moving the ship ahead or astern and breasting her in at the same time.

CASE 2.

If the ship has way, either ahead or astern, her *momentum* enters into the problem of her behavior. We have here another application of a spring, the power involved in this case being furnished by the ship itself.

In Fig. 3, Plate **103**, suppose that the steamer shown is moving parallel to the face of the dock with engines stopped and helm amidships, and that the stern spring A K is taut. Disregarding the resistance of the water, which is inconsiderable, the motion of the ship will be that resulting from her momentum along the original course and the tension along A K. The tension on A K may be resolved into two components; one retarding the ship along the line of her original course and thus directly opposing the momentum, the other hauling her in toward the dock and tending at the same time to turn her about the center of gravity, drawing the stern in and throwing the bow out. It is important to note, however, that the momentum, which is concentrated at the center of gravity, *forward of the pivot*, opposes the turning and tends to keep the ship straight. Thus as a matter of fact the ship does not turn much in cases of this kind, but comes in nearly parallel to the dock (Fig. 4, Plate **103**).

CASE 3. (Figs. 1 and 2, Plate **104**.)

If the vessel is moving as before, but with a spring from the bow instead of from the stern, the forces acting are similar to those in the preceding case, but with an important difference. In the present case, the momentum acts to increase the turning effect of the spring, instead of opposing it. This will become clear if Fig. 2, Plate **104**, and Fig. 4, Plate **103**, are compared.

The result of this difference is that the *bow* of a ship moving ahead on a bow-spring turns sharply in toward the dock, whereas the stern is turned in very little, if at all, by a stern-spring.

If the ship is moving astern, instead of ahead, the conditions are of course reversed, a stern-spring turning the stern in sharply, while a bow-spring has little effect.

Evidently, in both of the preceding cases, the turning moment is greatest when the line is made fast at the extreme bow or stern. If it is made fast at the center of gravity, the ship should (theoretically) spring in without turning, provided her draft of water is the same forward and aft. We shall presently see that if the helm is to be used (as in practice it always is) the maximum control of the ship will be obtained when the line is made fast at some point intermediate between the end of the ship and the center of gravity.

CASE 4.

Suppose that the vessel of Case 2 (Figs. 3 and 4, Plate **103**) puts her helm to starboard with a view to throwing her head in. Since the steering effect of the rudder is chiefly a matter of moving the stern of the ship, and since the stern cannot be thrown off to starboard because it is held by the spring, it follows that starboard helm can here have comparatively little turning effect. This assumes, of course, that the line is made fast over the rudder. Port helm, on the other hand, will help materially to throw the stern in.

If in Case 3 (Figs. 1 and 2, Plate **104**) the helm is put to starboard, it will throw the stern off and greatly increase the rapidity with which the bow turns in. If put to port, it will oppose the turning, but not enough to overcome it.

If in any case we make fast the line at the center of gravity while the ship is working ahead, we shall spring the ship in bodily but can at the same time *steer* her by putting the helm over, throwing the stern to either side as desired; the ship swinging on a pivot under the influence of the helm, while coming bodily in on the spring.

If the line, instead of being made fast amidships, is taken to a chock between the midship point and the stern, say midway between, we gain a considerable steering power, without entirely sacrificing the turning tendency of the spring. In practice, the spring is usually taken to this point—or to the corresponding one between the midship point and the bow—and this is found to give a convenient balance of forces and to admit of working in with the ship under good control (Fig. 3, Plate **104**).

CASE 5.

If we add to the factors already considered, the effect of the screw, going ahead or backing, we have the conditions of actual practice in cases where the tide is not strong enough to be considered.

So long as the screw is turning *ahead* it has a powerful steering effect through the action of the discharge current against the rudder, driving the stern off to the side to which the helm is put, the bow being held in by a spring. In *backing*, its effect may be utilized to throw the stern to one side, but not to the other. If it is right handed, it will throw the stern to port and cannot be prevented from this even by hard over port helm. It is for this reason that single-screw steamers (right handed) are most easily put alongside with the port side to the dock. They can run in at a considerable angle, then stop and back and so straighten up parallel to the dock, whereas with the starboard side in, backing would throw the stern further off.

Vessels with twin-screws have the same advantage in working around a dock that they have in manœuvring elsewhere; that is to say, the screws can be utilized to turn the ship even when she has no steerage-way, and when, therefore, the rudder has little effect. This use of twin-screws—going ahead on one and backing the other—is obvious enough; but there is another application which can be made of them which is often overlooked. As noted above (and as explained at considerable length in the chapter on "The Steering of Steamers"), a right-handed screw, in backing, throws the stern to port, while a left-handed screw throws it to starboard. In a single-screw steamer we have, in this action of the backing screw, a powerful force acting to one side, which may be utilized with great advantage *if we wish to throw the stern to that side.* If it happens that we wish to throw the stern to the other side while backing, or to hold it steady, then this action of the screw is a disadvantage, and often a serious embarrassment. But in a twin-screw steamer we have *both a right-handed and a left-handed screw,* so that we may, in backing, throw the stern to either side by using the proper screw. It is the general practice to put the right-handed screw to starboard and the left-handed screw to port. If, therefore, we wish to throw the stern to port while backing, we back with the starboard screw alone; and it should be noted that not only does the direct action of the screw throw the stern to port, but the leverage due to the position of the screw (to starboard of the center of gravity) acts in the same direction. Similarly, if we wish to throw the stern to starboard, we back on the port screw alone.

Effect of a Current.

If there is any current, it must of course be reckoned with and may be the most important factor in the situation because the one which cannot be controlled. Slack water is the most favorable time for working around the dock; but a head tide, if not too strong, may be used to advantage. A fair tide is unfavorable, and should be avoided if possible in coming alongside. A weak tide setting on to the dock may be helpful, but a strong one is very dangerous. A tide setting off increases the difficulty of the situation, but reduces its danger.

In considering the effect of the tide, it must be remembered that a vessel with a current on the bow not only has her headway checked, but is set bodily off to the opposite side. For this reason, care must be taken to avoid getting too much of a cant across, as this may result in being set in with dangerous violence.

A ship held stationary in a current, whether by her own power or by a line, may be canted to either side by the use of the helm, exactly as if she were moving through the water. Thus, with a head tide, a line may be run out from the bow to the dock well ahead, and the ship dropped in by the tide alone, the speed with which she comes in being regulated by the helm.

§ II. PRACTICAL CASES.

In considering the handling of a steamer around a dock, a distinction must be made between the case in which she uses her own power alone and that in which she is assisted by one or more tugs. All very large vessels are now handled by tugs and it would be the height of imprudence to attempt to dispense with them. But vessels which would formerly have been considered very large are constantly worked in and out with their own resources alone. Such are the splendid vessels of the Sound and Bay Lines of the United States, some of which are side-wheelers and others propellers. These vessels run on schedule time and without reference to tides. They are brought alongside their piers often under the most unfavorable conditions, and rarely meet with an accident. It should be noted, however, that these vessels are especially designed for this business of docking under all conditions of wind and tide. Most of them have guards extending much farther out from their sides than any of the projections which might interfere with docking.

The Marine Superintendent of one of the large Atlantic steamship companies writes to the author on this subject as follows:

"In my opinion, the great secret in handling either a twin-screw or single-screw steamer in approaching a pier, is not to have too much way on the ship; the engines should be slowed and the way off the ship so that she can be kept well in hand at such a distance from the pier, that if it should be necessary to go ahead in order to cant the ship's head either one way or the other by the use of the rudder, it can be done without the ship's overrunning the place where she is required to land. The ship should be kept thus in command until she gets into a position where she can be stopped entirely by moving the engines astern, without risk of her bows striking the pier, or of her getting out of position by her head canting off by the action of the propeller moving half or full speed astern. If the pier is approached in this manner, after a little practice it is astonishing how close even the largest vessels can be brought to the pier without danger of colliding. Large steam vessels should always approach a pier against the tide, and as near parallel with the direction of the tide, or trend of the river, as possible. The practice of heading a ship from the river between two piers is a very doubtful and frequently dangerous operation; for, although the tide may be slack on the surface it may be running smartly either flood or ebb for a few feet below."

Handling a Steamer without Tugs.

Having to go alongside, if there is any choice in the matter, select a time as near as possible to slack water; which, it must be remembered, does not necessarily or usually correspond to high or low. If any current is running, manœuvre if possible to bring it ahead, running beyond the pier and turning if coming in with the flood. With a single-screw steamer, there is an advantage in putting the port side to the dock (supposing the screw to be right handed) but this is of less importance than is the direction of the tide.

A vessel does not go alongside without some preparation having been made, and there are usually men stationed to receive and handle her lines. If not, a gang must be sent ashore for this purpose; and in any case, a boat should be ready for lowering, with the men either in it or standing by. Fenders should be at hand, lines on deck and clear for running, with heaving lines bent, anchors ready for letting go, capstans and winches ready for heaving, boat-davits and every thing else alongside rigged in or cleared away as far as possible. Most merchant vessels are designed with some reference to going alongside, although it is impossible in any ocean-going vessel, to avoid the projection of boat-davits and some other obstructions. In men-of-war there are also guns and sponsons to be considered; and in twin-screw ships, whether men-of-war or merchantmen, the screws project many feet beyond the side and constitute a danger which must never be forgotten for a moment. To keep these vessels off, there are usually provided floats or "camels"; and these must be hauled into position by the shore gang at the points where they are seen to be needed.

The simplest case that can arise is that in which a right-handed screw vessel is to be put alongside at slack water and port side to the dock. Here she is run in at a small angle to the face of the dock, and the engines backed in time to throw her stern in and straighten her up. This does not mean that she should come in at such speed and at such an angle that if the signal to back is misunderstood or if the engines are slow in responding, the bow will crash into the dock. Other things being equal, the more nearly parallel to the dock she is brought in, and the lower the speed used, the better; but as some backing will probably be called for and as the effect of this will be to throw her stern in, a little allowance should be made for it.

Another way of making a landing under the above conditions is to get out a line from the quarter, and, going ahead very slowly, spring her in on this, using the helm to hold her parallel to the dock. A line used in this way must be carefully attended and checked slowly as the tension on it approaches the danger point. It should preferably be taken from a chock about half way between the midship point and the stern, as this gives good control of the ship by the helm as she comes in.

Under the same conditions, if the port side is to the dock, she might be sprung in by backing on a bow line, but this is not so good a way, since the control of the ship in backing is altogether unsatisfactory. If the starboard side is to the dock, the effect of backing would be to throw the stern off, so if this method is to be used, a stern spring will be needed in addition to the bow spring (Fig. 4, Plate **104**). The use of two springs like this is very common.

Plate No. 105.

Fig. 1

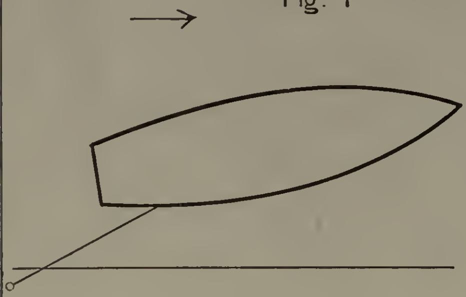


Fig. 2

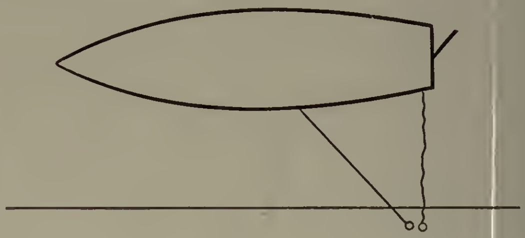


Fig. 3

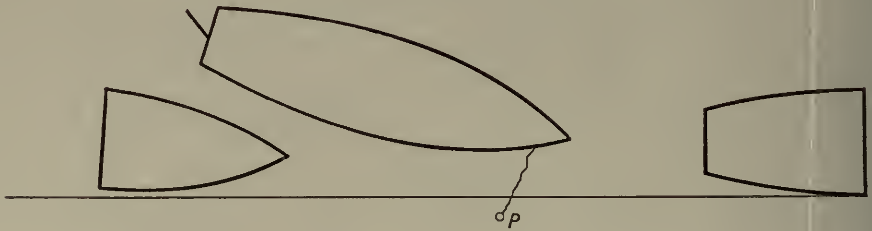
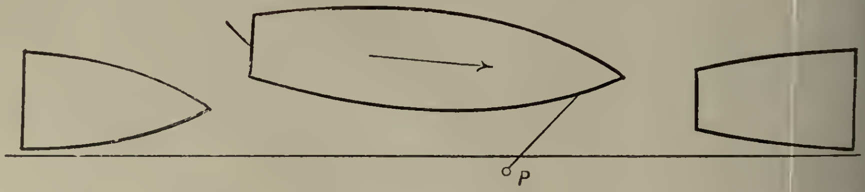


Fig. 4



HANDLING STEAMERS AROUND A DOCK

A *twin-screw* ship may be backed down on a bow line and sprung in with comparative ease, the helm being used to keep her fair with the dock, and the right- and left-handed screws used as has been explained above.

If there is a head tide, the vessel may be brought up with hardly more than headway enough to stem it until a bow spring is run, then allowed to drop back on this by the tide and so come in to her berth. Care will be needed to see that she does not get too strong a cant across, as this would set her in with dangerous force. She can be steered without difficulty by the helm, giving a turn ahead with the screw if necessary from time to time. In this way a vessel may drop in from a considerable distance out. She may even dispense with the line for coming in, taking the tide a little on the bow and letting this set her in bodily; care being taken, as before, that she does not come in too fast, the helm and engines being used to straighten her up when necessary.

It does not always happen that the tide sets parallel to the face of the dock. More frequently, it sets on at more or less of an angle, and the angle often varies with the stage of the tide. At Old Point Comfort, for example, the current at one stage of the ebb runs along the face of the dock, while at another stage it sets directly on. Between the two extremes, it turns slowly from one of these directions to the other. Similar phenomena to this are common in all places where fairly large bodies of water are involved and especially where the channel bends or where several channels meet. Another point to be remembered is that the surface current often has a very different direction from that which is running underneath. Considerations like these make it clear that local knowledge is essential for docking ships with safety, and suggest that in places where the phenomena of currents may prove to be complicated, a stranger having to dock his ship should seek the assistance of a pilot with full knowledge of local conditions.

If it should be necessary to make a landing with a fair tide, preparations must be made to get out a stern line promptly, and the vessel should be brought abreast her berth (or a little astern of it) *with a slight cant of the head outward* (Fig. 1, Plate **105**). This will prevent danger of the current catching her stern on the inside and sweeping her off while the line is being made fast, as might happen if her head were canted in.

It is an invariable rule that with a fair tide, the ship must be sprung in with a stern line, never with a bow line alone; and the same rule applies in springing her in by her own headway. In either of these cases, the effect of a bow spring would be to throw the stern off, while a stern spring, for reasons which have been explained in Section I, brings her bodily alongside.

If the dock is not clear ahead and astern of the berth to be occupied, other means must be employed. The vessel may be laid abreast her berth as close in as practicable, and hauled in one end at a time by lines taken to winches. In this case, if there is no tide, the stern should be hauled in first, the bow line being slack and the bow allowed to swing out as the ship turns. This because it is always harder to haul in the stern than the bow, owing to the drag of the after body and the screw. The stern, having been hauled in somewhat, is held from swinging out by a breast line, and the bow is hauled in. The operation is then repeated if necessary, the stern being held in each time while the bow line is manned, but the bow being allowed to swing out a little each time as the stern comes in. Thus the working in of the stern is a matter of *turning* rather than of dragging in bodily, while with the bow, the reverse is the case.

If circumstances admit of going ahead somewhat, the following method is perhaps the simplest that can be employed. A spring is run from a point well forward but still abaft the center of gravity, and a breastline from a chock near the stern to a point on the dock nearly abeam (Fig. 2, Plate **105**). The screw is started ahead slow with helm hard aport (supposing the port side is to the dock) and the stern swings in on the spring, from the effect of the port helm. When she is canted as much as is thought best, the stern breast is hauled taut and held, and the helm shifted to hard a-starboard, the engines being kept ahead slow. The starboard helm now tries to drive the stern off, but the breast holds it, and, as the ship forges ahead on the spring, the bow turns in and is held by a bow breast. The helm is presently shifted to hard aport (the engines all the time going ahead) and the stern comes in again. The operation is repeated as often as may be necessary; care being taken, if a current is running, to avoid getting too much of a cant.

Still another way of working into a restricted berth is shown in Figs. 3 and 4, Plate **105**. This supposes that there is no tide,

Plate No. 106.

Fig. 1

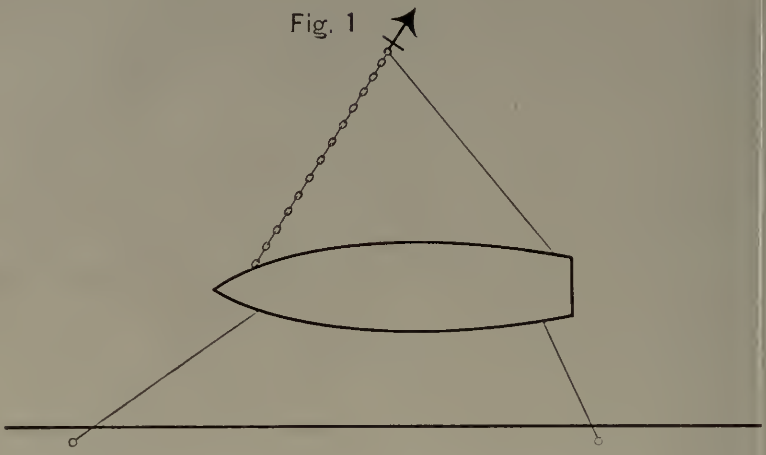


Fig. 2

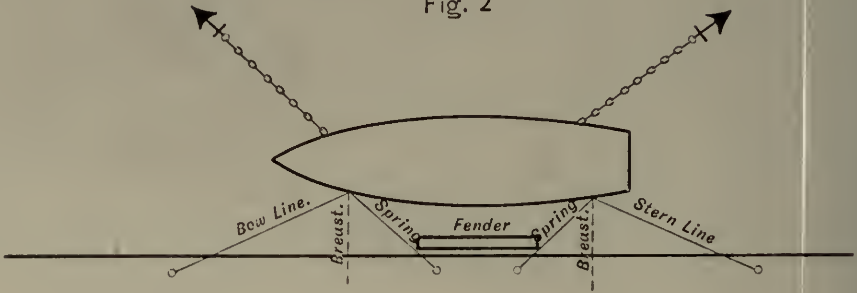


Fig. 3

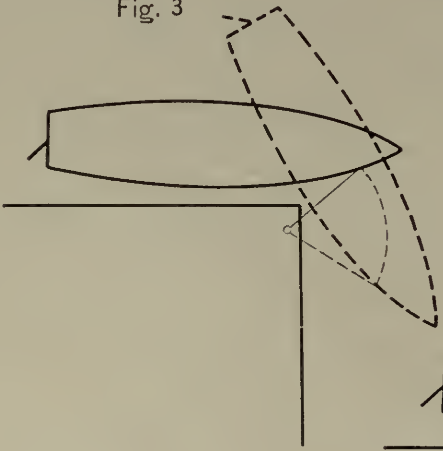
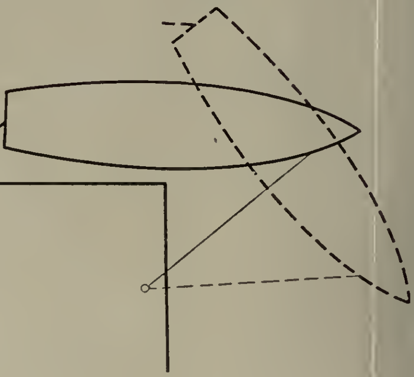


Fig. 4



HANDLING STEAMERS AROUND A DOCK

Come in at such an angle as may be necessary to clear the danger astern, putting the bow close enough to get a line ashore to some point as P, abaft the point where the bow is to be when secured. Go ahead with starboard helm, which will throw the stern in, leaving the bow line slack until the stern clears the danger; then hold on the bow line, still going ahead with starboard helm. This brings her into her berth.

Under many circumstances, as for example when proposing to lie for some time at an exposed dock, an anchor should be let go outside and some distance ahead of the berth to be occupied, and the ship dropped or hauled in from this by the aid of bow and stern lines to the dock. With a head tide, a judicious use of the lines and the helm will make it possible to drop in with little or no hauling, but she must be straightened up toward the end to avoid coming in too heavily. If an anchor is needed from the quarter, this must be laid out later by a boat.

With a fresh breeze or a current setting on to the dock, it may be possible to drop in by letting go an anchor abreast of the berth with a spring from the quarter made fast to the ring (Fig. 1, Plate **106**); bow and stern lines being used as before.

Fig. 2, Plate **106**, shows a vessel secured to the face of a dock with bow and stern lines, bow and stern breasts, and with offshore moorings for holding her off.

§ III. WORKING INTO A SLIP.

Where a vessel is to be worked around into a slip, she usually makes a landing first at the outside of the pier and is then turned either ahead or astern around the corner, swinging on a spring from near the end of the dock. It is easier to put the head in than the stern, because of the use which may be made of the helm for steering around and into the new berth. Account must be taken of the current, and allowance made for the fact that its principal effect will be felt upon the part of the vessel which swings out into the stream—not upon the part inside the slip.

We consider first the case in which there is no current (Fig. 3, Plate **106**). The vessel goes ahead sufficiently to bring her bow well beyond the end of the pier, and a line is taken from the bow to a point on the pier near the corner around which she is to turn. If the line is made fast close to the end of the pier, the tension on it is nearly a straight pull, and the turning effect is very slight. It should therefore be taken a short distance up the slip, to give a good turning effect with comparatively little strain upon the line. If, however, it is taken up too far, the ship will make a large sweep in coming around, going over to the farther end of the slip. The same effect will be produced if the bow is allowed to lap too far beyond the pier before the spring takes the strain. The effects of different conditions here may be foreseen in any given case by remembering that the point of the ship at which the line is made fast will follow the arc of a circle around the bollard on the pier.

The spring may be greatly assisted and the tension on it relieved, by making use of the helm to swing the stern out at the beginning and to steer her into place after she is pointed fairly in.

In the early part of the turn, the bow of the vessel will hug the corner of the pier, owing to the lead of the spring and the disposition of the ship to turn about her own center of gravity, throwing her stern out and her bow in. Toward the end of the turn, the same factors act to throw her off, although if rather a short spring is used, her bow will always be held in more or less closely. If it is not desired to hold her close in—because of boats or guns which might be endangered—her bow should be allowed to lap well over beyond the pier before beginning to turn, and a longer line used. The line should also be made fast farther aft on the bow and taken farther up the slip, and the helm put hard over in the beginning. All of these points will tend to prevent binding against the corner as she turns (Fig. 4, Plate **106**).

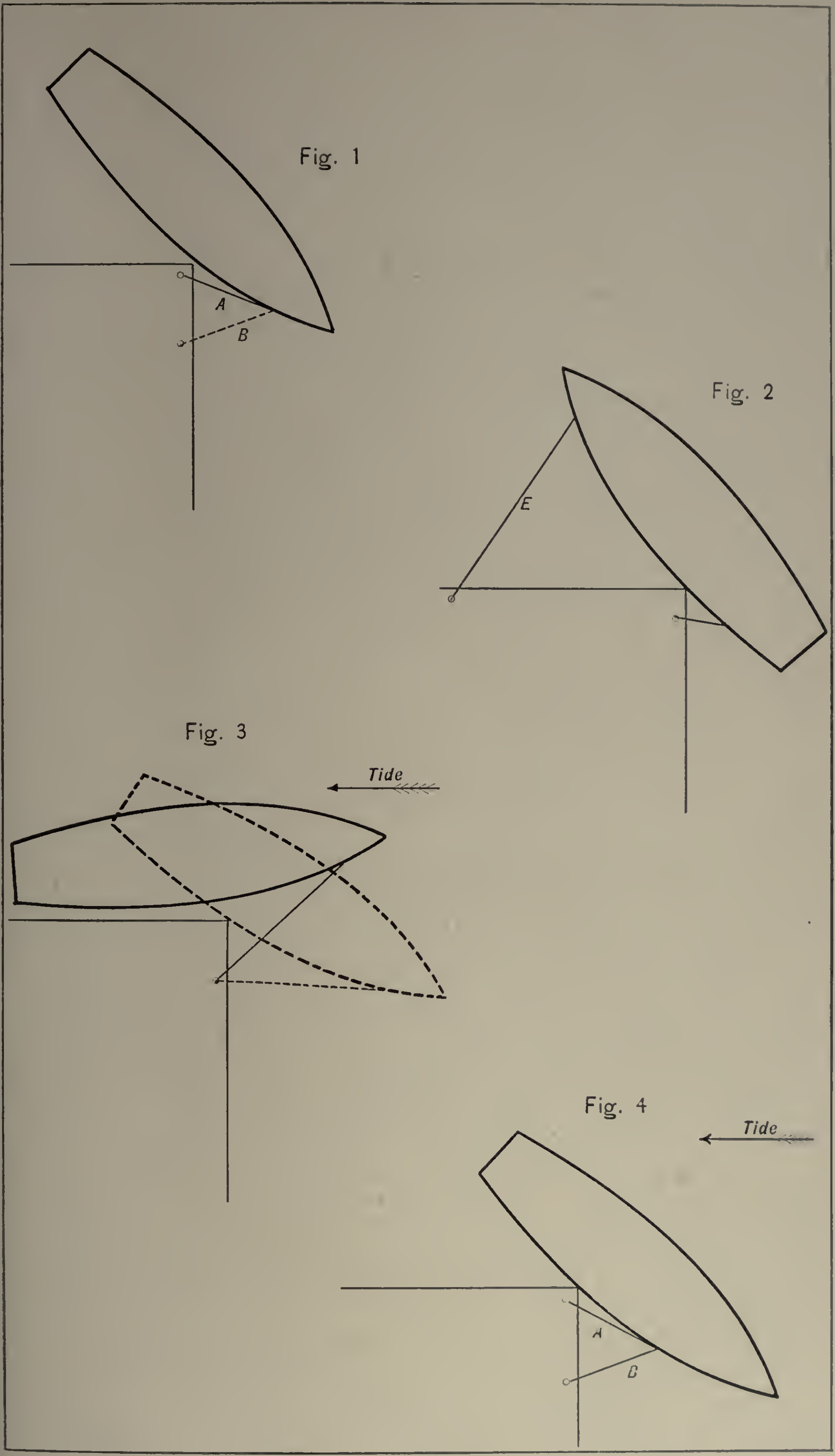
If the spring used is a short one, it will presently have a lead too nearly in line with the keel to continue its turning effect at a favorable angle, and will, if continued in use, be subject to an undue tension (A Fig. 1, Plate **107**). It should be replaced before this point is reached by another line, B, having a better lead.

In making use of two lines in a case of this kind, where the lines must cross, care should be taken to keep the line which will be first let go, under the other.

A stern line is commonly used as shown at C, but in this particular case, there being no current and the vessel being under control by the helm, this line is not important.

In *backing* around into the slip, the same principles hold; but here the helm is not of much assistance, although it should be used and will help somewhat. In this case, a bow line (E) is needed to keep control (Fig. 2, Plate **107**).

Plate No. 107.



HANDLING STEAMERS AROUND A DOCK.

If there is a current, it must of course be allowed for. If proposing to work against it, as in Fig. 3, Plate **107**, we must remember that the ship will be set down hard against the corner of the pier until she is fully inside the slip, and that a great deal of power will be required to overcome the effect of the current acting against the quarter as the stern is thrown out into the stream. Here there will be an advantage in using a comparatively long spring and allowing the bow to project well beyond the pier before beginning to turn. The tendency to swing out from the pier will be counteracted by the tide. It will be especially important under these conditions to shift the spring before it leads too nearly fore and aft. A vessel held as in Fig. 4, Plate **107**, for example, would probably not turn at all, while she would put a tremendous strain upon the spring. The whole situation is modified by substituting the line B for A. The vessel can now gather headway (going ahead with her engines), and work into place. The second line, (B), having been run, A is eased away until B has the strain, after which A may be shifted up the dock, and take its turn later as replacing B.

A large vessel could not be turned in this way against a strong tide without the aid of tugs to pull her stern around.

If the tide is fair, as in Fig. 1, Plate **108**, the danger is that as the stern swings out into the stream it will be swept around with such force that the stern line cannot hold it. This line (technically the "swinging" line) should be a good one and carefully attended by several men. The spring should be short and taken from a check not very far forward. It will then help to hold her up, at the same time that it springs her around. As she swings out, the swinging line must at first be eased away roundly; but there will presently come a time when, as she moves into her berth, this line slacks up, and the slack must be gathered in rapidly to prevent her being swept down across the slip. At the same time, the spring, having done its work by pointing her fairly in, is let go, and she is steered inside, bow and stern lines being used to hold her in to the pier. These lines should be shifted frequently and used principally as *breasts*, not as springs. If her stern has swung too far over, it may be sprung in by the original swinging line or by another spring run for this purpose.

With a large ship and a strong tide, this method is not to be thought of, as the stern line would inevitably part and the stern sweep down across the slip with every probability of serious disaster.

If the ship is to be *backed* into the slip, the principles involved are the same, but the difficulties are somewhat greater because of the comparative lack of control by the helm. It should be remembered, however, that even in backing, the helm is of some value and should always be used. Even in cases where the ship is not moving through the water, the suction current of the backing screw is drawn in against the rudder, with an effect which may be utilized to more or less advantage.

For hauling into a dry dock, slack water is very important, because of the narrow space available and the exactness with which the ship must be pointed and held. A current from any direction is troublesome, but one running across is especially so

Yet if high water is essential it may be necessary to accept some inconveniences in this matter. An officer whose ship is to be docked should make himself familiar with the currents with which he will have to deal—and this none the less because the docking is usually directed by local authorities.

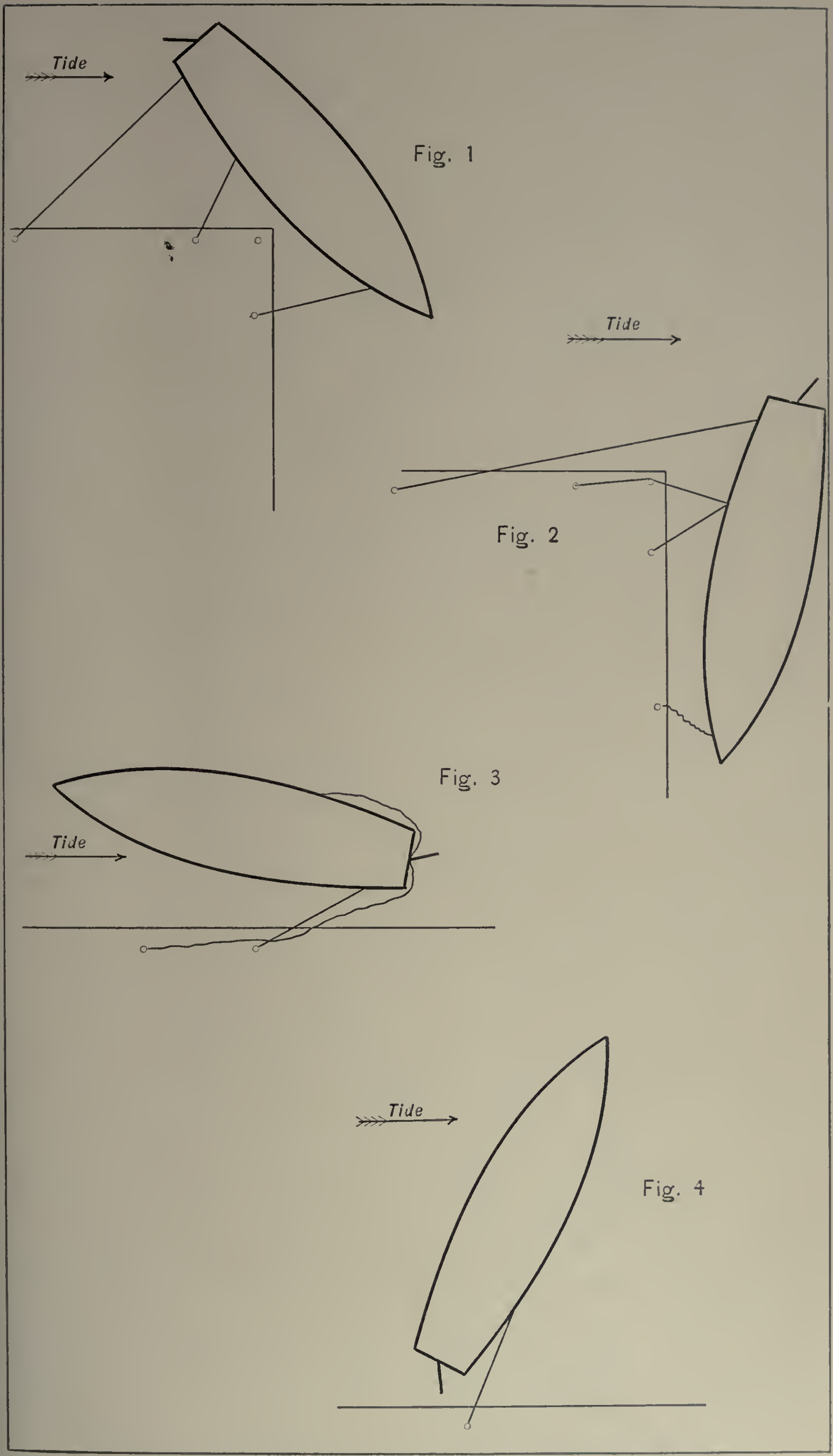
For hauling into the dock, the ship must be pointed fair by such means as the situation of the dock and the facilities provided may suggest. At large establishments, tugs are usually at hand for hauling the stern around. In the absence of these, lines are run from the quarter for hauling it around, while the bow is held by good lines from either side of the entrance. A line for hauling in is taken to the head of the dock, and extra lines are used wherever they may be necessary.

To Wind a Steamer at a Dock.

To turn a vessel end for end as she lies at the dock is a manœuvre of considerable difficulty in cases where there are no means of hauling off the bow or stern.

It may be done in a tide-way as follows: Suppose the port side is to the dock and that it is desired to put the starboard side there (Figs. 3 and 4, Plate **108**). Select a time when the tide is running feebly from ahead. Cast off all moorings but a breast forward and a spring aft. Back on the stern spring and ease away the bow breast, letting the tide catch her on the inner bow. As she cants out, let go forward and hold on to the after spring. Run a line from the *starboard* quarter fairly well forward, passing it

Plate No. 108.



HANDLING STEAMERS AROUND A DOCK.

around the stern and holding the bight up clear so that it cannot foul the screw. Make fast the other end of this line well up the dock. The tide will set her out from the dock at the same time that it swings her. As soon as the screw is clear, go ahead slow with helm aport, taking care not to throw the stern in against the dock, and to keep the line from the starboard quarter clear of the screw. She will forge ahead, slacking the inner (port) spring, which may be let go and gotten out of the way. By a careful use of the helm and engines, the stern may be worked up the face of the dock but well clear of it, until abreast of the point where it is to rest when the vessel has been turned. The slack of the starboard spring is then taken in and the line made fast. As she turns, bringing the tide more and more on her broadside, she will drop down until this line holds her stern, when she will begin to swing more rapidly. As her bow turns in toward the dock, the engines may be backed if necessary to hold her stern up to its place, and even to throw it off a little from the dock if she is coming in too fast. The effect of this is to let the tide meet her a little on the inner bow as she swings in, and so to check her somewhat. It is supposed, of course, that proper fenders are in use; and here it may be remarked that in all cases of handling large steamers around docks, fenders should be used of such *length* that as the ship comes in on them, the pressure on her side will be distributed over a large number of frames, not localized at a single point.

If it becomes necessary to wind a ship when there is no tide to turn her, it may be done in much the same way as above, but with a little more use of engines, helm, and lines. Her bow must first be canted out a little by such means as may be available. This may be by backing on a stern spring, by pivoting on a float, or by any other method which may be suggested by the conditions of the case. Care must be taken to keep the screw clear. Having canted the bow out slightly, go ahead slow, and as she moves out from the dock give her as much port helm as she will stand without swinging the stern in too far. In this way work her up along the dock, canting her out more and more. In the meantime, a line is run from the *starboard* quarter but well forward toward the midship point. This must be carefully attended to keep it clear of the screw. When she has turned out sufficiently to give this line a clear lead, it is held on and acts as a spring. Going ahead on the engines with helm hard aport will now turn her head rapidly, and she may be worked around and into place without much difficulty. The fact that the spring is made fast near the midship point, gives a good leverage for the steering effect of the rudder, whichever way it is put.

If the starboard side is to the dock and it is proposed to wind her, it may be better to back around, as the effect of the screw (right handed) will be to throw the stern out and to turn her as is desired. In this case, take a line around the bow to the port side a little forward of the midship point. Leave this slack in the beginning. Go ahead on a starboard bow spring until the stern is canted out slightly, then back with helm hard starboard, holding on to the port bow line. The stern will swing around rapidly, the spring holding her up and in. When she is nearly around she may be worked in at any point desired by going ahead or backing on the engines, using the helm to steer her to her place.

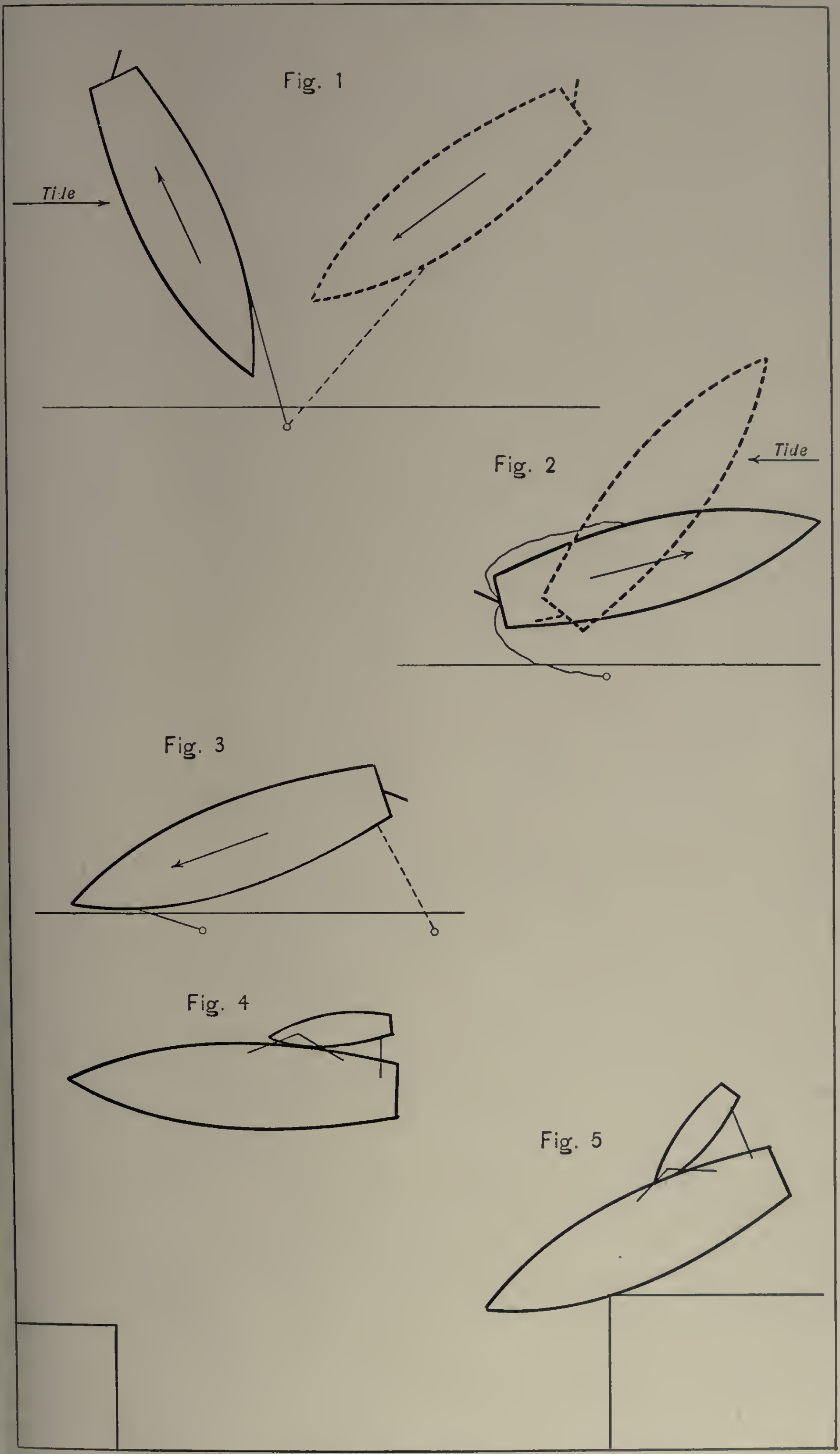
It is frequently necessary to wind a vessel in making a landing. Say the tide is fair and the dock to starboard, that it is desired to put the port side in, and that there is not room to run beyond the pier and turn (Fig. 1, Plate **109**). Make as much of a sweep as space permits, putting the bow in near the place where it is to be, and run a line from the port side a little forward of the midship point. Back slow with helm hard a-starboard and let her swing on the line. When she is nearly around, she may be steered into place by going ahead on the engines and using the helm.

If the tide is running out and it is desired to turn, the conditions being otherwise identical with those of the preceding case, run up to the other end of the berth and get out a line from the port side a little abaft the midship point, taking it around the stern and keeping the bight up clear of the screw. Go ahead with starboard helm and she will turn on the spring and work into place (Fig. 2, Plate **109**).

It is possible to wind a small steamer by putting her stem against the dock and going ahead with helm hard over to the side which will throw the stern out and swing it around. A large steamer handled in this way would probably cut through the dock.

Freight and passenger steamers frequently have to hold their bows in against the dock for discharging cargo from the forward

Plate No. 109.



HANDLING STEAMERS AROUND A DOCK

deck. In such cases they use a spring as in Fig. 3, Plate **109**, and keep their engines turning slowly ahead with the helm hard over to the side which will throw the stern off. A steamer will lie this way for an indefinite length of time even though the tide may be ahead. If the tide is aft, a stern line is used to assist in holding her.

GETTING CLEAR OF A DOCK.

In preparing to get clear of the dock, all lines should be singled, and as many as can be spared got out of the way; all permanent fasts let go and hauled to the dock, spur-shores cleared away, and men stationed by the line which will be the last cast off.

It is convenient to select a time when a feeble current is running along the face of the dock, to set the bow or stern out (the line at the other end being kept fast), thus getting a cant for working out, either ahead or astern. In the absence of such a current, advantage may be taken of a breeze setting off from the dock, or the bow may be swung in more or less by going ahead slow on a bow line with helm hard over to the off-shore side. She may then be backed off clear.

Care should be taken in all cases, but especially with twin-screws, to keep the screw clear of the dock.

With a current or a fresh breeze setting onto the dock, it will be necessary to provide some means of hauling out, and for this purpose a tug is most convenient, unless it happens that a line can be run to a buoy or to a neighboring dock. If an anchor has been dropped in coming alongside, it will of course be useful now. In the absence of any other means, a stream anchor may be laid out without much trouble.

It is sometimes necessary to get clear of a dock where the current always runs strongly in one direction, as in a river. Officers having this to do as a part of their regular business become very expert at it. A case in point is the Peiho River, at Tientsin. The river is only just wide enough for the steamers trading there to swing from shore to shore, and the tide runs four or five knots and never slacks. Steamers lie alongside with head up stream, port side to dock, and when ready to turn for going out, having a full head of steam, they cast off all but a line from the starboard (off-shore) quarter, and swing out into the stream. The bow sweeps around with great rapidity athwart the current, and down the stream. At just the right instant, while heading three or four points across and down, the starboard quarter line is cast off and the engines started full speed ahead with helm hard over.

§ IV. HANDLING A LARGE VESSEL WITH THE AID OF TUGS.

In some cases tugs are used for actually towing the larger vessels; in others, merely for turning them, holding them up against the tide, etc.

A tug having to tow a large vessel in docking is usually placed on the quarter which will be away from the dock, with a line for going ahead and another for backing, both of which are taken from the *bow* of the tug to some convenient point on the other vessel. A breast line is also run from the stern of the tug to prevent her from swinging off (Figs. 4 and 5, Plate **109**). A tug placed like this is favorably situated for turning to either side by going ahead or backing.

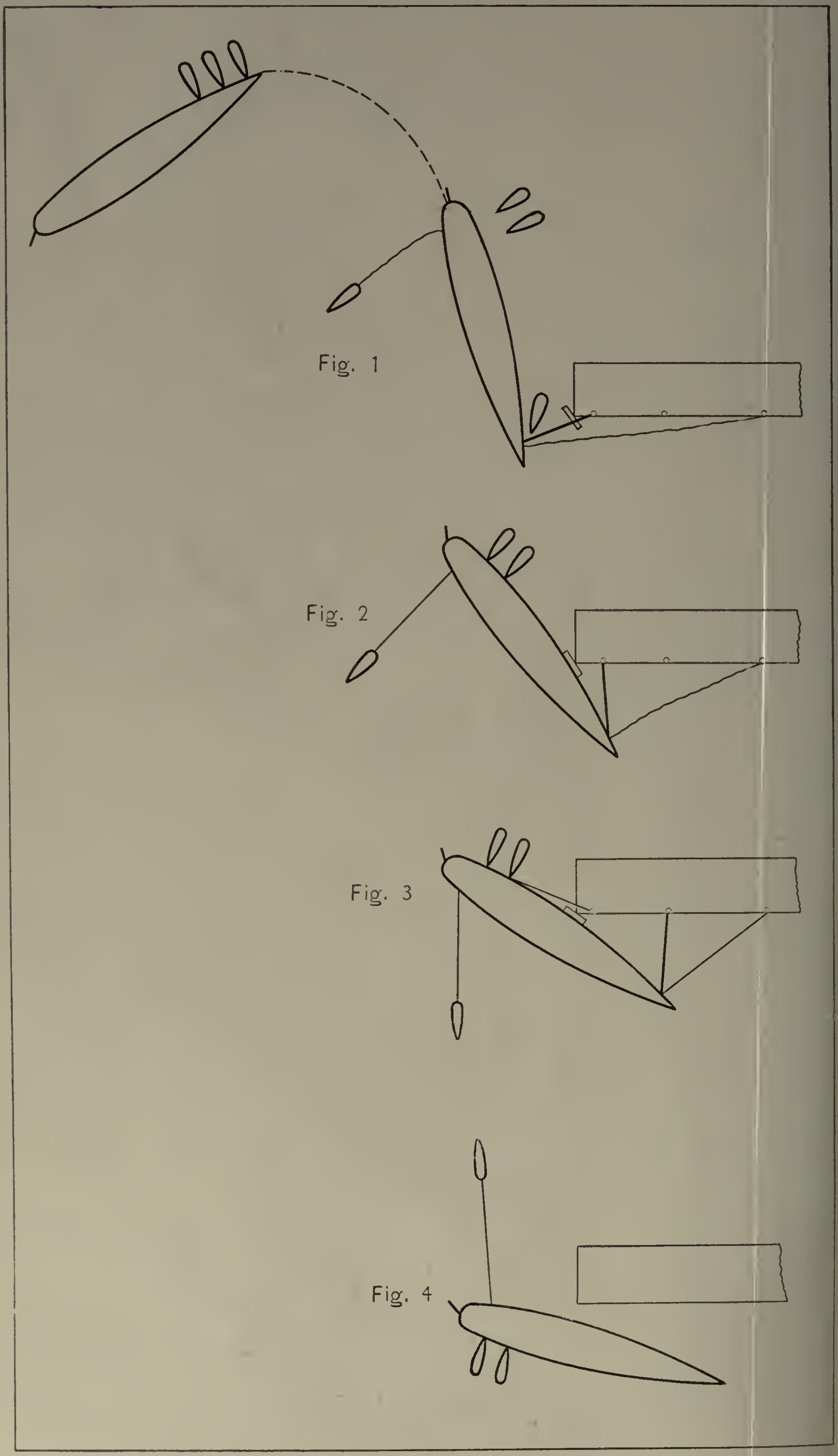
In some cases it is found convenient to place a tug on the off-shore bow. This is in case the vessel must be brought to the pier with a considerable cant inward. The tug on the bow is well placed for bringing her in like this and for hauling the bow out at the last moment while the stern is being worked in.

In docking large ocean liners, a number of tugs (frequently as many as six) are used for turning the vessels and for holding them against the tide as they work into their slips; but such headway or sternway as is needed is generally given by the engines of the vessels themselves.

In this, as in all other cases of working around a dock, much use is made of the helm; and if the vessel has twin-screws, these are used also, in connection with the tugs, for turning her.

The tugs may take lines from the bow or quarter, or they may point their stem-fenders against the side, and push. Spring and check lines are used as in the cases already described, but are not trusted to the same extent for checking the vessel or for springing her around. They must be large and very carefully attended. If allowed to lead fore and aft or nearly so, they will almost inevitably carry away as the ship forges ahead upon them. They should therefore be frequently shifted as she moves along the dock, being kept approximately at right angles to the side.

Plate No. 110.



Docking a Large Steamer.

The following description of berthing a large Atlantic liner on the New York side of the North River is contributed by an officer of many years' experience in such work. As the tide is running flood (to the northward) the ship is berthed on the south side of the pier (see Plate **110**).

On the flood tide, the ship comes up the river on the Jersey side and is turned completely around, above the pier, by the aid of tugs which are placed with their fenders against the port bow (Fig. 1, Plate 110). After the ship is turned nearly parallel with the tide or with the trend of the river, one tug is usually kept alongside on the port bow, in case the ship's head should require to be canted to starboard, the other tugs backing away ready to be placed on the port quarter. As soon as the ship is near enough to her pier, heaving lines are sent off to her by a small rowboat and by means of these the bow-lines are run. These lines are led some distance up the slip. Another heaving line is carried to the ship and a hauling line of about 3″ manila is sent from the ship to the pier, where it is made fast with a long bowline through the eye of an 11″ manila hawser which is faked on the end of the pier, near the southeast corner. When ready, the 3″ rope is taken through a forward pipe to one of the ship's winches, the hawser hove on board and the eye hove over the bitts. This line is for helping to slew her around into the slip. The ship is then allowed to go as far ahead as possible before the strain is permitted to come on the spring (Fig. 2, Plate 110). Great care must be taken that the ship does not get too much of a cant towards the pier, with the tide too broad on the starboard bow, as it is most important that these heavy vessels should not be permitted to approach the corner of the pier sideways at any great rate of speed, but gradually. We have had instances of ships taking the corner of the pier with apparently only a moderate force and denting plates and bending frames to such a degree that it was a question of thousands of dollars to place the hull of the ship in its original condition. We use for a fender a spruce built log, about 40 feet long by 30″ by 24″. This log is fitted with chains and ropes so that it can be handled from the pier and placed in any position required. It is laid across the corner of the pier for the ship to land on at the water line, so that instead of one or two of the ship's frames taking the pier, she is landed on a dozen or more. As soon as the ship takes the fender, signal is given to the tugs and they commence to push her port quarter out into the stream. One tug is usually placed on the starboard quarter attached to a hawser, while two or more push on the port quarter. With a twin-screw ship it is necessary to have at least this one tug on the starboard quarter to prevent her quarter from taking the corner of the pier with a flood tide running, endangering fouling the port propeller. The bow ropes by this time are passed some 150 or 200 feet up the pier. When all is ready, the signal is given to the bridge, starboard engine "Slow Ahead," helm starboard. The ship gradually swings towards a line at right angles with the trend of the river with her bow pointing into the slip. As she comes around, the *check* is slacked away to permit her to go ahead, and bow-lines are shifted as required (Fig. 3, Plate 110).

The after ropes are run by the small rowboats, sometimes by tugs, as soon as her quarter nears the end of the pier. As she moves into her berth, the bow and stern lines are kept as nearly abreast as possible, by short fleets, and the ship's stern kept as close to the pier as is prudent, always taking into consideration the care that must be observed not to foul the port propeller. The engines can move the ship ahead or astern as much as necessary. There is a 12″ check rope on the pier near the berth, ready to be hauled on board into one of the after chocks on the lower deck. There is also a wire pennant passed out from one of the chocks from the lower or spar deck, with an eye, in which is to be hooked the block of a threefold purchase block leading from the pier.

When she has sufficient way to reach her berth, she is placed in proper position by lines and tackles which are entirely in the hands of the shore gang on the pier.

The warps used on these vessels are 7″ and 8″. The lines themselves must never be passed forward from the stern chocks, but heaving lines used when it is necessary to pass forward any distance away from the quarter, as great care must be taken that these warps are not allowed to foul the propellers. In handling the check from the end of the pier, the shore end should be fleeted as often as possible as the ship goes ahead, in order that the strain may not be brought too much fore and aft. Of course the nearer the check is kept at right angles with the line of the ship, the less strain will be required on it to cant the ship's head, and when it is nearly fore and aft almost the slightest way on the ship will carry it away, unless the greatest care is observed.

Leaving the Slip.

We undock these ships from both north and south side of the pier at any stage of tide.

When undocking from south side of the pier, with tide running strong ebb, an 11″ line is taken from the port quarter to one of the largest tugs (Fig. 4, Plate 110). Extra men are placed on the tug to assist in handling this rope. Two or three moments before the sailing time, the tug starts ahead to the northward and pays out perhaps 75 or 80 fathoms of scope. As the stern of the ship is about 100 feet inside the end of the pier, this hawser is rove through a thimble spliced into a 4 tail rope. This slip rope is taken around the post at the south corner of the pier with three or four turns, and the end held by some of the shore gang, to prevent the bight of the hawser from flying into the crowd that is usually on the dock at sailing time. When the ship is far enough astern for the bight of the hawser to clear the corner of the pier, the slip rope is let go. The end of the hawser attached to the ship is fitted with a lashing eye (old cargo falls are used for the lashings) and the eye hove over one

> of the bitts. When the ship is turned head to the southward, this lashing, at a signal from the bridge, is cut on the ship; the eye of course flies clear of the vessel and prevents any danger of fouling the propeller. In addition, one or two tugs are used to push on the starboard quarter. As soon as the ship is partly out of the slip these tugs let go the quarter and proceed to the port bow. With the aid of the tugs on the port bow and the one attached to the hawser, the ship of course is swung with her head to the southward, and when far enough around the tugs are let go and ship proceeds.
>
> With the flood tide, two or three tugs are ready to put their stems against the port quarter of the ship. As soon as the propeller is well clear of the pier these tugs are to ease the ship off the corner as much as possible. For sliding out we have a built spar, 50 or 60 feet long by 20″ by 24″. This spar is slung abreast of a plate on the ship's side that is clear of sidelights and coal ports, and is secured firmly to the pier by chains and heavy ropes. The outer side of the spar is sheathed with 2″ spruce that can be easily replaced as it becomes broken or splintered.

For handling a large liner when her own engines are not available, at least six tugs would be used; one on each bow (ahead) one on each quarter alongside and one on each quarter with a single line. The tugs alongside are especially for stopping the vessel's way when necessary, though of course they assist also in moving her ahead and in turning.

CHAPTER XVIII.

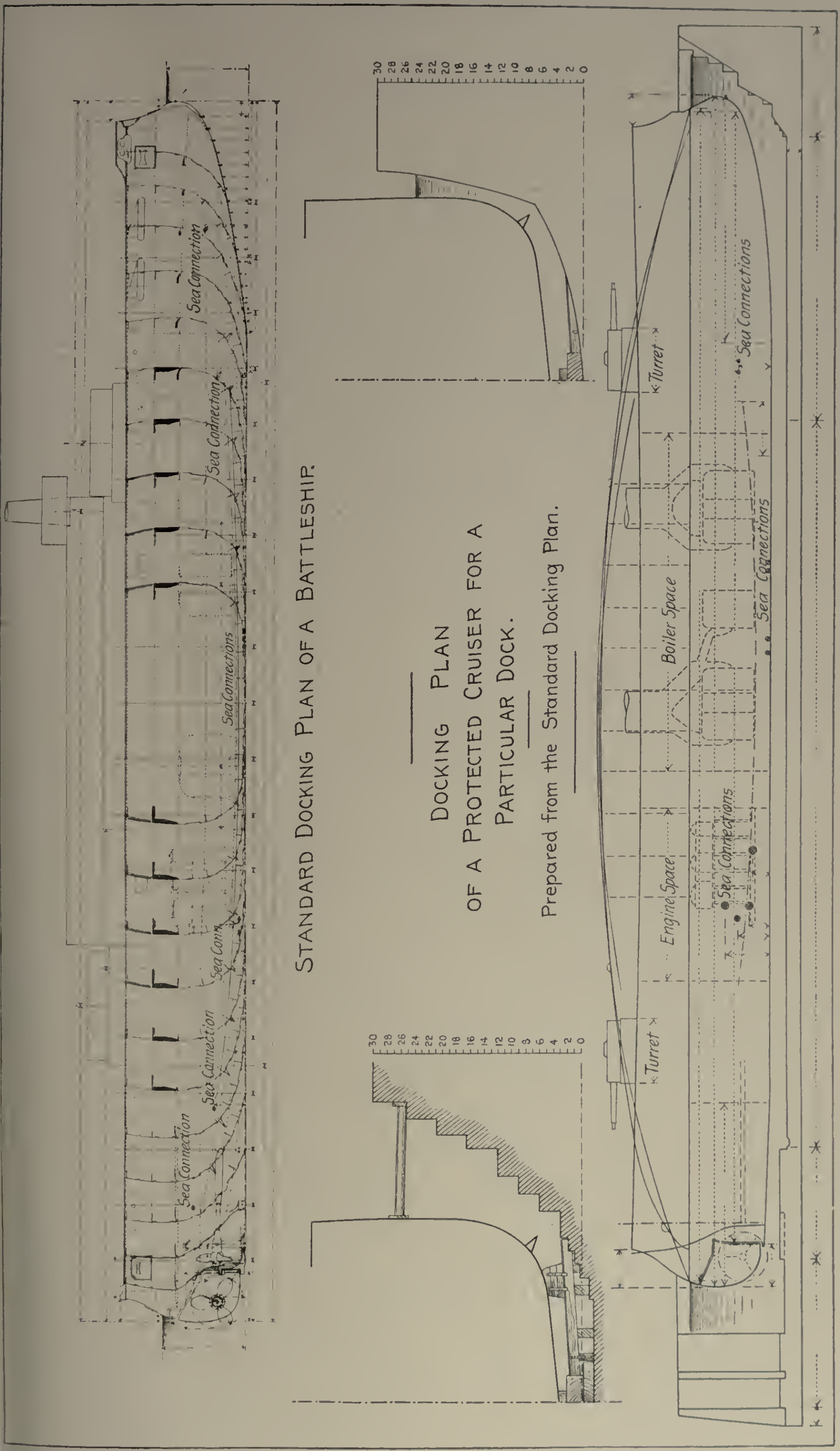
PLACING A SHIP IN DRY DOCK.

The operation of safely placing a ship in dry dock, safely supporting her with blocks and shores, and afterwards floating her out of dock, is so common that the care and experience necessary to ensure success in this operation are not generally understood, yet it is possible that very serious damage may occur during the operation, if intelligent supervision be neglected.

Every ship should carry a docking plan which shows: the length on the load water line; the length over all; the location of all the under water valves; the locations of the water-tight bulkheads, the engines, the boilers, the turrets (if any), and such other weights and fittings as are peculiar to any particular ship; the length of straight keel, together with dimensions locating accurately the cut-up (if any) of the dead wood aft, together with any peculiarities of the stern post and rudder; also such dimensions as will show the curvature of the forefoot, especial care being taken to locate the exact point where this curvature departs from the straight line of the keel. The docking plan of a battleship is shown on Plate **111**. The docking plan should also contain information as to cross-sections amidships and elsewhere, showing the beam at or near the water-line, the shape and location of the keel, the docking keels and bilge keels, the struts, the propellers and all other objects below the water-line; in other words, the docking plan must furnish all necessary information concerning the under-water hull and its accessories, also dimensions as to projections above the water-line which increase the nominal beam of the vessel: the latter information is frequently of extreme value in foreign ports whose docks have their dimensions tabulated with reference to merchant vessels only.

In our navy yards, blue-prints of such plans are usually in the possession of the Naval Constructor—elsewhere it is necessary to furnish such plans to the responsible authorities of public or private docks—without them, the efficiency and safety of the docking are absolutely dependent upon the skill and experience of those having control of the docks.

Plate No. 111.



STANDARD DOCKING PLAN OF A BATTLESHIP.

DOCKING PLAN
OF A PROTECTED CRUISER FOR A
PARTICULAR DOCK.

Prepared from the Standard Docking Plan.

The dock master of any particular dock being given the docking plan of a ship to be placed therein, proceeds as follows: knowing the ship's draught, the maximum depth over the sill, together with the current and tidal variations in the vicinity, he decides upon the time the vessel should enter the dock, and so informs the commanding officer, who thereupon makes the necessary arrangements to ensure that the vessel at the time specified shall be absolutely upright, without any list either to starboard or port.

The entrance to a dry dock may be closed by hinged gates, a floating caisson, or a sliding caisson; the first and last methods are often used in foreign docks, but in home docks, a floating caisson is most commonly found; it usually has a ship-shape form with sufficient stability to safely float upright when empty; to sink it, valves are opened which admit water to its interior, and to raise it, all outboard valves are closed and the water it contains is pumped overboard.

The dock floor carries along its center a line of blocks, called "keel blocks." These are usually of wood and are secured to the dock floor in various ways. Their distance apart varies in different docks, but it is customary to place these keel blocks much closer together under turrets and other heavy local weights on war ships, than is done with ordinary vessels. Those ships having straight keels, but whose fore-foot is cut away, are supported forward by building up the corresponding keel blocks to suit the contour shown on the docking plan. With ships having docking keels, a double line of keel blocks is provided, running parallel to the center line and at the proper distance therefrom, given on the docking plan. At intervals along the bottom of the dock and at right angles to the center line, are the bilge ways, along which slide the bilge blocks which can be moved towards or away from the center line by the hauling lines which are manipulated from the dock coping. Each bilge block is built up of a proper height and level, as determined from the docking plan, so that after the vessel's keel rests upon the keel blocks, the bilge blocks can be hauled and accurately fit against the bottom, thus thoroughly supporting the ship before the water has been pumped out of the dock. Care is taken that the bilge blocks are not hauled so that they will bear against an under-water valve or other accessory which would be injured by heavy local pressure. In foreign docks, bilge blocks are rarely used, shores being fitted to sustain the bottom after the dock is empty.

To maintain the vessel upright after she has grounded on the keel blocks, and before the bilge blocks are hauled, wale shores are used, one end resting against the ship's side, the other against the dock's side, wedges being used to set them taut. These shores are prepared of the desired length and placed in the vicinity of their final location by means of information obtained from the docking plan. Certain marks are also made on the coping which will accurately locate the ship's position in the dock, in order to ensure that as the water is pumped out, the under-water hull shall exactly coincide at the proper time with the various blocks and shores which have been made ready to receive it. Plate **111** shows the plan which would be prepared for a particular dock after receiving the docking plan of the vessel which was to be placed therein.

These preparations being completed, water is admitted, the caisson is floated and removed, and the dock is then ready to receive the ship. After the ship's bow has safely entered the mouth of the dock, the responsibility for her safety rests upon the dock master; the methods of securing this safe entrance are considered elsewhere. The dock master then hauls the ship into the dock until certain definite objects near her bow and stern coincide with the marks which he has laid out upon the dock coping in accordance with the docking plan. The caisson is then placed in position, the pumps which empty the dock are started; their operation between this time and the time of the complete emptying of the dock being controlled by the judgment of the dock master.

In the meantime the necessary arrangements have been made to ensure the ship being safely centered in the fore and aft and athwartship directions, and the wale shores have been floated and placed approximately in their proper positions: during this period, by the use of sighting battens or other means, the variations of the ship from the upright are finally determined, and the necessary measures are taken to correct any listing to starboard or to port.

Under ordinary circumstances, the ship's keel first touches on the keel blocks aft, and with a ship having a large amount of drag, special precautions are necessary to prevent listing, because, under these circumstances, stability is lessened very rapidly. The grounding of the keel aft upon the keel blocks is indicated in various ways, but before this occurs, the dock master has arranged the wale shores so that any inclination towards listing or twisting shall be prevented as far as possible. The entire line of wale shores is not set up tightly until the forward portion of the keel is bearing upon the keel blocks prepared to receive it. As the water level within the dock becomes still lower, the keel blocks are hauled, and the ship during the remaining period of her stay in dock is supported by the keel blocks, bilge blocks, and shores.

After the dock is emptied, the ship's bottom is thoroughly cleaned and careful examination is made of the entire bottom as regards fouling, corrosion and damage. All outboard valves, propeller struts, propellers, shaft bearings, rudder pintals and gudgeons, strake edges, butts, etc., are carefully examined. It is usually necessary to re-grind the underwater valves, and to re-pack the stuffing boxes of valves and of the rudder; if the plating butts show lines of rust, they should be re-calked; if the rivet heads show serious corrosion, the rivets should be removed and new ones driven; if there is serious corrosion or pitting, the plating should be thoroughly cleaned and brushed before re-painting; in cleaning the bottom from fouling substances, care should be taken that the paint underneath is disturbed as little as possible; zinc rings and zinc plates at the openings of outboard valves, and in the vicinity of the propellers, should be renewed if their corrosion shows galvanic action. The bottom is then given fresh coats of anti-corrosive and anti-fouling compositions, which should be applied whenever possible, on dry surfaces.

If special repairs have been anticipated or are found to be necessary after the dock is empty, the necessary action is taken immediately, because the length of time a ship remains in dock must be reduced to the minimum.

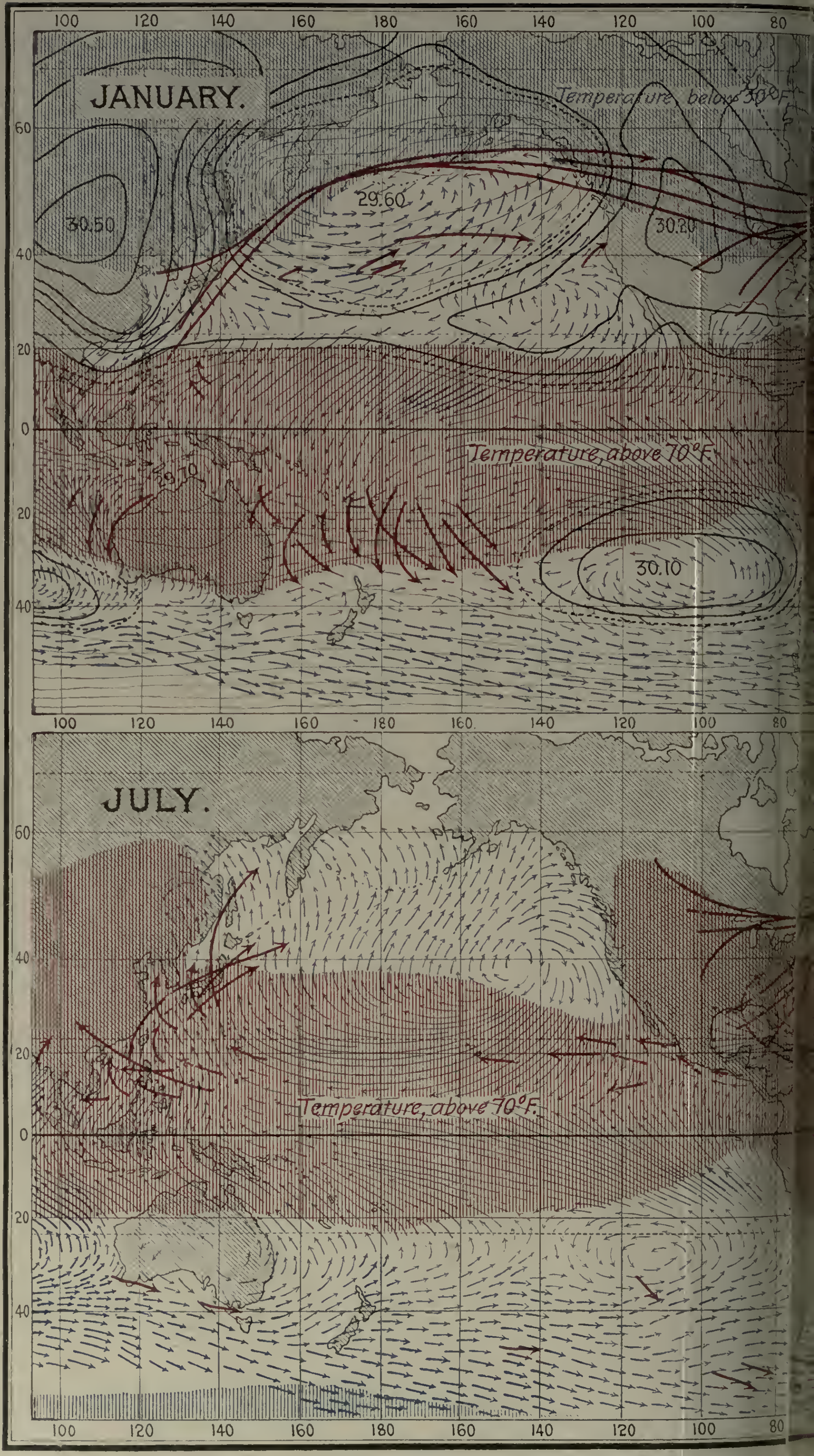
The particular precautions which must be taken in docking ships which are not in ordinary condition, must depend upon the judgment of the dock master.

During the period that a ship is in dock, no change of any kind in the distribution of her weights should be made without the knowledge and consent of the dock master, because the ship when being floated might suddenly change her trim so as to cause serious damage to herself or to the dock.

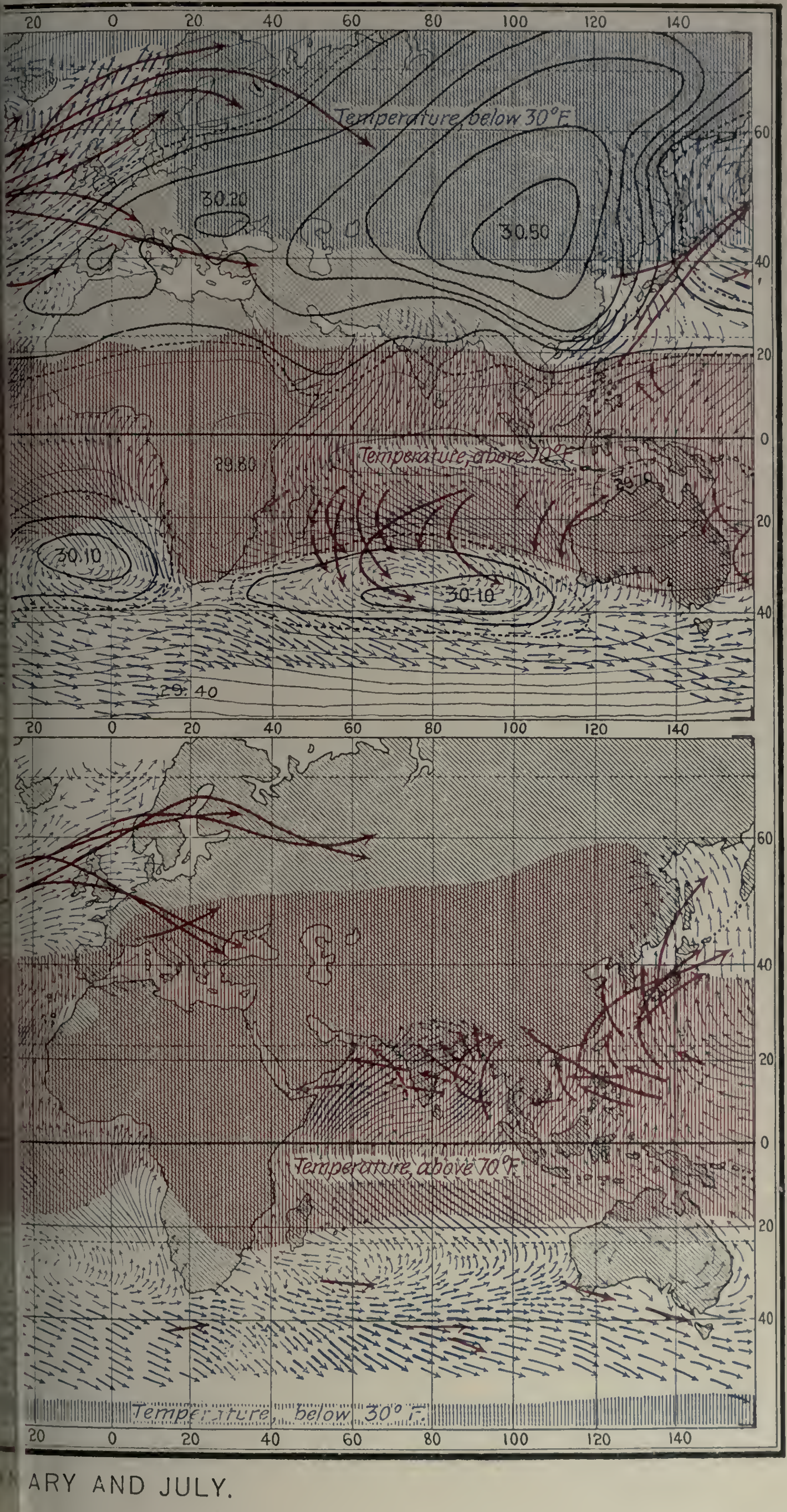
The painting of the bottom, and all under-water repairs being completed, a time for flooding the dock is agreed upon by the commanding officer and the dock master. The former stations men at the outboard valves and elsewhere, as he deems proper to ensure that water does not enter the ship, and the latter stations men at the various shores and lines and elsewhere, to prevent as far as possible, any injury to dock or ship, from a change of weights or an unexpected alteration in tide or wind.

The water in the dock enters continuously under the dock master's control. When it has risen to a sufficient height, the bow ordinarily first lifts from the keel blocks, and shortly afterwards the stern. If there has been any material change of weights while the ship has been in dock, she will suddenly and violently take a list to starboard or to port, with consequent damage to herself and the dock.

The ship being safely afloat, the water is allowed free entrance until the level within the dock coincides with that outside, after which time the caisson is floated as quickly as possible, then removed, and the ship is floated out of dock.



WINDS AND WEAT


Temperature, below 30°F.
30.20
30.50
29.80
Temperature, above 70°F.
29.70
30.10
30.10
29.40
Temperature, above 70°F.
Temperature, below 30°F.
20
0
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40
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ARY AND JULY.

CHAPTER XIX.

WEATHER AND THE LAWS OF STORMS.

§ I. WEATHER, WINDS, CLOUDS, RAINFALL.

The subject of weather may conveniently be studied in its general features by reference to a map showing normal or average conditions at different seasons of the year. Plate **112** gives such a map, showing normal winds, barometer pressures, and temperatures, for January and July, throughout the world with the exception of the extreme polar regions. The curves in black are "isobars" or lines of equal barometric pressure. It will be seen that these lines are, in the main, closed curves about areas of high or low barometer;—the distinction between a "High" and a "Low," as these areas are called, depending not upon the actual height of the barometer, but upon the way in which the wind circulates about the area; or, more accurately, upon whether the characteristic pressure is the result of ascending or of descending currents. It is clear that a high pressure is the natural accompaniment of descending currents of heavy air, and vice-versa; but whereas a barometric height of 30 inches may indicate a rising current at one place and time—which would make it a Low;—it may indicate a descending current at another place and time, and may thus be a High. It tends to clearness, therefore, to use, instead of "high" and "low," the terms "cyclone" and "anti-cyclone," which define the wind circulation instead of the pressure resulting from this circulation. As thus used, the term cyclone has no necessary connection with a gale. It defines simply a condition of affairs in which an ascending current of air at a more or less clearly marked central area is surrounded by an inflowing spiral whirl which may or may not take on the concentrated and intense character with which we commonly associate the term cyclone. Similarly "anti-cyclone" defines a condition of affairs in which a descending current of air develops into an outward flowing spiral whirl with a motion of rotation opposed to that of the cyclone (Plate **113**). Both of these phenomena will be more fully described hereafter.

The relative positions of the warm red and cold blue tints on Plate **112** show January as winter in the northern and summer in the southern hemisphere; and July as summer in the northern and winter in the southern hemisphere. The bounding lines of the red and blue tints are the isotherms (lines of equal temperature) of 70° F. and 30° F. respectively. It will be noted that the thermal equator—as the middle of the equatorial hot belt may be called—does not coincide with the geographical equator, but fluctuates in a way which is evidently influenced by the seasons, continents, oceans, and winds.

When air is heated, it expands and becomes lighter; it therefore rises, and the ascending currents cause a decrease of pressure. Another important result follows in the formation of clouds and rain due to the presence of aqueous vapor in the ascending current. As the air rises it expands more and more, cooling at the same time through the absorption of heat due to this expansion, while it is still further chilled by the lower temperature of the upper regions of the atmosphere. As a consequence of the reduction in temperature, much of the aqueous vapor is condensed into clouds or precipitated in rain, giving off a large amount of heat, which tends to rarefy the air still further and so to intensify the upward draft.

We have here, briefly outlined, an explanation of the weather characteristics, which in some degree mark all regions of low barometer and cyclonic circulation, whether these extend over thousands of miles of ocean and continent as in the cases shown on Plate **112**, or are localized in the narrower and more intense form of tropical hurricanes. The weather of all such regions is characterized by more or less cloudiness, frequently accompanied by rain, by low barometer, and by winds which, while not necessarily violent, are usually stronger than in an anti-cyclone, since the determining cause of these winds—an upward rush of warm air with the attendant features that have been described—naturally takes on a somewhat more violent form than does the downward current of cool and heavy air which is the determining cause of anti-cyclonic circulation.

The velocity of the wind, as well as its direction, depends upon relative pressures in adjoining areas; being determined by the steepness of the "barometric gradient," or the amount of difference in the reading of the barometer for a given distance. This is well illustrated in the cyclone and anti-cyclone of Plate **113**, in which the distance between the successive iso-

Plate No. 113.

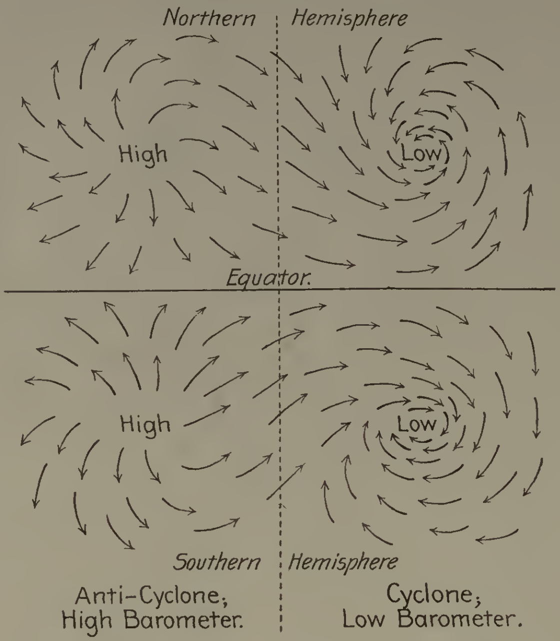


FIG. 1. CHARACTERISTIC WIND CIRCULATION ABOUT CENTERS OF HIGH AND LOW BAROMETER IN EACH HEMISPHERE.

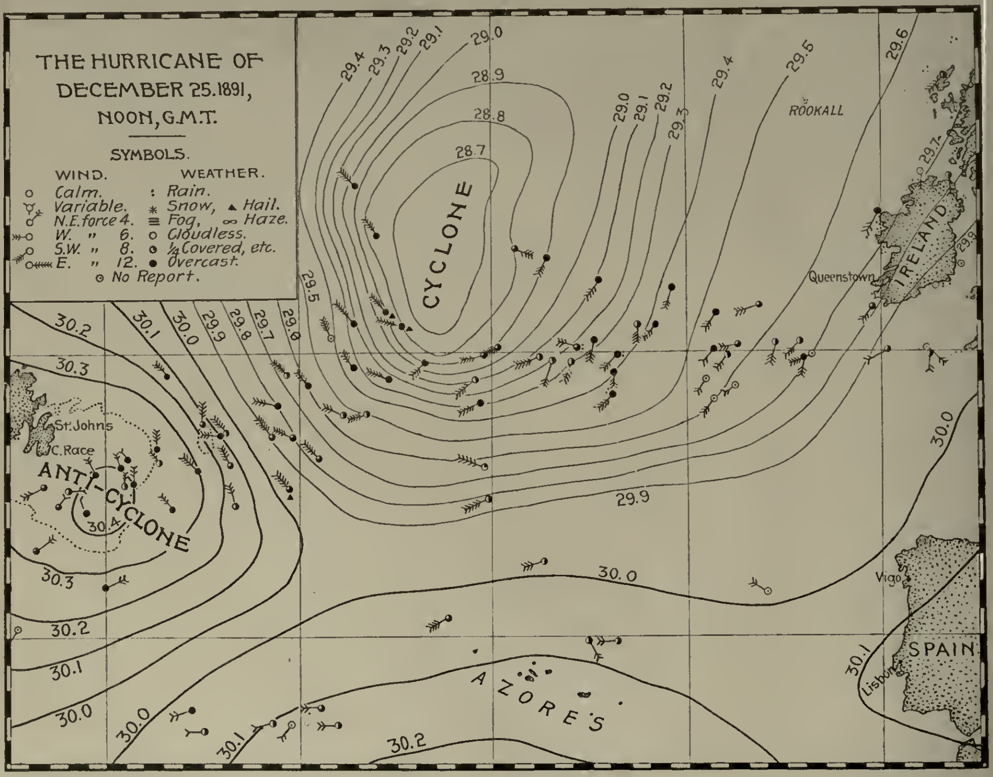


FIG. 2.
CYCLONE AND ANTI-CYCLONE IN THE NORTH ATLANTIC.

bars indicates the steepness of the barometric gradient. Where the isobars are crowded closely together, the change in pressure is very great for a small change in position; or in other words the gradient is very steep. At such places the velocity of the wind is high. Where the isobars are separated more widely, they indicate a gradual change in pressure or a gradual slope to the gradient, and here the winds are more moderate.

To compare barometric gradients, they are commonly reduced to hundredths-of-an-inch per 15 sea miles. On this scale the steepest gradient ever observed was in the cyclone that passed over False Point, India, in September, 1885. This gradient was 238; which means that in a distance of 15 miles, there existed a difference in barometric reading of $2\frac{38}{100}$ inches.

It will be observed in Plate **113**, that the wind blows partly across and partly along the isobars, forming the spiral whirl which has been elsewhere described.

The following description and explanation of a sudden shift of wind over the North Atlantic Ocean is from the Pilot Chart of the U. S. Hydrographic Office for July, 1900 (Plate **114**).

It illustrates in a very striking way the relation between the direction of the wind and the barometric pressure.

> During the course of March 17, 18 and 19 last, the steamers along that portion of the transatlantic routes lying to the eastward of the meridian of 60° experienced a sudden shift of the wind from S.E. to N.W., accompanied by a marked increase in force, as indicated by the following table. The shift progressed steadily eastward, the date and hour at which it was noted aboard the several steamers distributed along the lane depending upon the position of the various vessels at the time, becoming successively later as the longitude diminished.

Vessel.	Date.	Long., West.		REMARKS.
Nederland..	Mar. 17	61°	35′	Strong to fresh breeze (from the South); at 8 a. m. wind shifted suddenly to NW.
Maryland...	Mar. 17	57	42	Southerly wind until midnight, when wind veered to NW. strong.
Minnesota..	Mar. 17	56	29	Southerly wind shifting at midnight to NW.; moderate gale.
Turcoman..	Mar. 18	51	27	At 3 p. m. wind shifted suddenly from South to N NW. and blew a moderate gale,
Anchoria...	Mar. 18	50	42	Wind SE.; at 5 p. m. wind hauled to W SW., later to NW.
Chester.....	Mar. 18	48	53	At 11 p. m. wind shifted (from S SE.) to NW., moderate gale.
Mokta.......	Mar. 19	48	22	At 2 a. m. wind shifted from S SE. to N NW.
Hekla......	Mar. 19	46	47	Wind S SE., 2, until 5 a. m., when it shifted through SW., West, to NW., 8.
British King	Mar. 19	46	00	At 8 a. m. wind shifted from SE. to NW.
Euxinia.....	Mar. 19	44	52	At noon wind suddenly shifted from SE. 5, to N NW., 6.
Symra......	Mar. 19	44	04	Wind from South; at 1 p. m. wind changed to W NW.
Helios......	Mar. 19	42	10	At 8 p. m. wind changed (from SE.) to N NW.

The meteorological conditions prevailing throughout this part of the North Atlantic at Greenwich mean noon of March 19 are shown upon the chart (Plate 113), where the symbols have the usual significance—the center of the arrow head marking the position of the observing vessel at the time of observation, the arrows flying with the wind, the number of feathers indicating the force of the wind, etc., etc. An inspection of the chart shows that the sudden shift of the wind (which several observers in their extended remarks stated was not announced by any decisive variation of the barometer, the mercury standing above 30 inches throughout) was due to the passage of the observing vessel across the shallow trough of low pressure which intervened between the two areas of high, each of these latter areas being surrounded by a well-developed system of anti-cyclonic winds, the light southerly and southeasterly winds proper to the rear of the preceding area being almost instantaneously supplanted by the strong northerly and northwesterly winds proper to the front of the following area. For the purpose of distinctness the outline of the trough is indicated by cross-hatching.

The several heavy dotted lines join the points at which the shift occurred at the same hour, the latter being indicated in the diagram. Thus along the entire length of the most western of these lines the shift was noted at 8.00 A. M. of March 18; along the next at 8.00 P. M. of March 18, and similarly for the others. Comparing the distance intervening between these lines it is seen to be in the neighborhood of three degrees of latitude or 180 nautical miles, giving for the eastward progress of the shift an average velocity of 15 miles per hour.

The indrawing air of the cyclone obtains its moisture by evaporation from the sea and from damp earth, or from areas of ice and snow if it passes over such. Its capacity for holding moisture in invisible suspension increases with the temperature; and for a given quantity of moisture so held, there is a perfectly definite temperature, called the "saturation point" or "dew point," below which the air cannot be cooled without giving out some part of its moisture in the form of cloud or rain. As already explained, this is why the warm moist currents from the surface of the earth, as they rise into the cooler regions of the upper atmosphere, produce the clouds and rainfall of cyclonic weather. It is the reason also, for the comparatively clear skies and dry weather of anti-cyclonic regions; since the cool dry air flowing from the higher regions downward and outward has its temperature raised and is enabled to take up into invisible suspension much of the moisture that it encounters, thus producing a comparatively dry atmosphere and clear skies. Naturally the farther we move from the center of circulation, whether cyclonic or anti-cyclonic, the less

Plate No. 114.

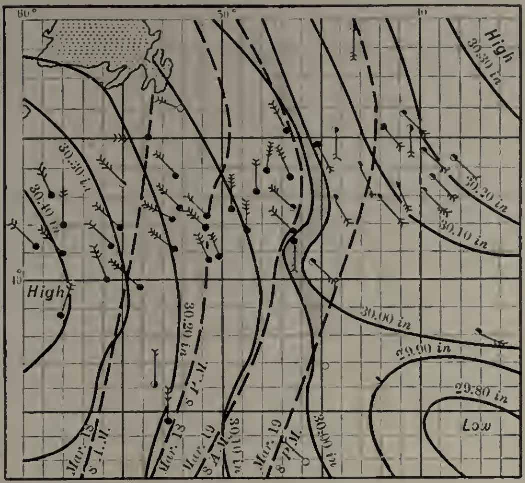


Fig. 1 Barometric Conditions over the North Atlantic causing a Sudden Shift of Wind.

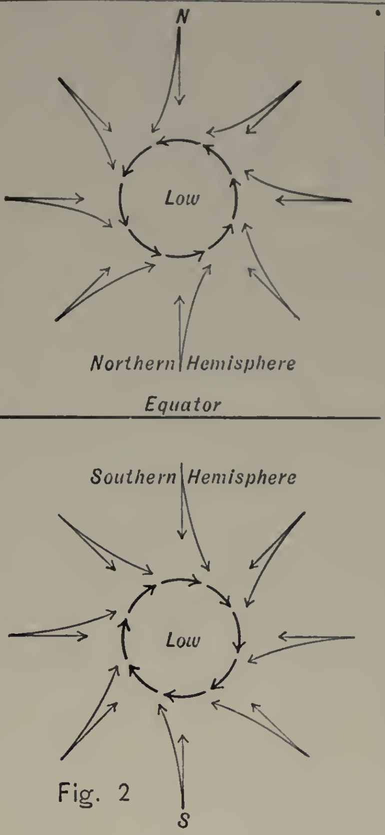


Fig. 2

Air flowing toward a "Low" and Diverging according to Ferrel's Law to form a Cyclonic Whirl.

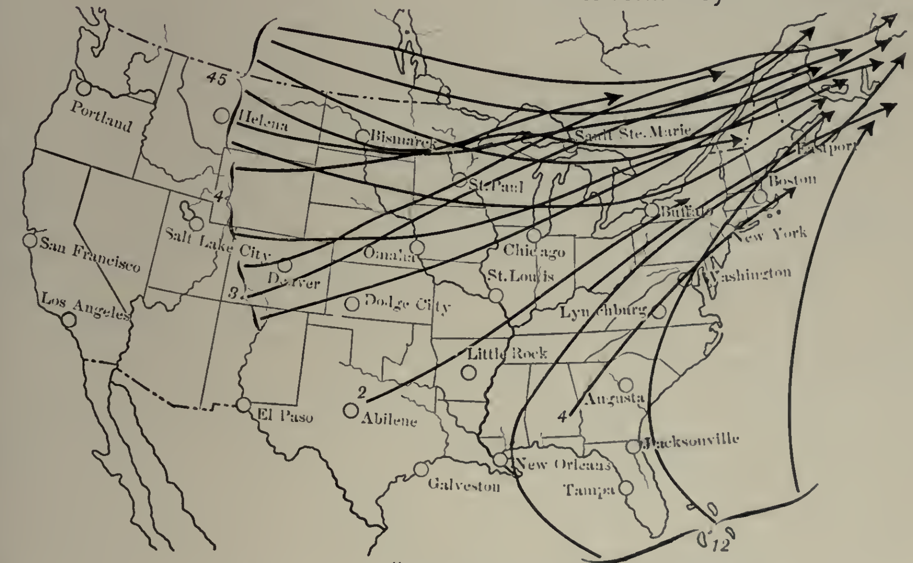


Fig. 3

From "Storms, Storm-tracks and Weather Forecasting" Published by the U. S. Weather Bureau.

Storm Tracks for August.

The Storms noted during 10 years are grouped according to their places of origin, the figures opposite the brackets indicating the number for each group.

STORMS AND STORM TRACKS.

marked these characteristics become. They may, moreover, be modified in many ways by local conditions of the land or sea over which they extend or over which they have passed; for all the features which would mark the weather of an ideal globe of uniform surface are modified in countless ways by the unequal distribution of land and water, and the varying physical features of both;—by currents, icebergs, etc., in the oceans; and by deserts, mountain ranges, and areas of forest or clearing on the land.

Thus the warm moist air over the Gulf Stream is chilled and turned into fog by contact with the cold Labrador Current off the Banks of Newfoundland. Similarly the southwest monsoon, charged with vapor from the tropical latitudes of the Indian Ocean, coming in contact with the cold heights of the Himalayas, precipitates its moisture in torrents of rain on the southern slopes of those mountains and passes on over the plains to the northward as dry as if it came from a desert. The proximity of a mountain range has always an important influence upon climate and weather.

GENERAL WIND CIRCULATION.

It would be natural to expect that in the great equatorial hot-belt, the phenomena of expansion from heat, of ascending currents with resulting low barometer, of condensation and precipitation of moisture, would be more frequent and more marked than elsewhere. Such is in fact the case; and Plate **112** shows clearly the great systems of steady indrawing Trades that meet in the region of equatorial rains and calms, and the connection of these with the great and generally permanent areas of high and low barometer that have been referred to as largely determining the circulation of the atmosphere about the globe.

As the Trades approach the equator there are constant little rising currents marked by the characteristic trade wind clouds; and in the region of permanent low pressure, calms, clouds and rain, which we have called the equatorial belt, but which is commonly known as the "Doldrums," they meet and rise, generally quietly and steadily but sometimes in the great eddies or whirlwinds with which we are familiar as tropical cyclones.

The tendency of the trades toward the equator from the north and south results naturally enough from the conditions which have been described as prevailing in the equatorial belt; but explanation is required of the westward component in these winds, as well as of the unvarying regularity with which the winds of cyclones turn always in one direction in the northern hemisphere and in the opposite direction in the southern, while for anti-cyclones these directions are reversed.

The theory which is commonly accepted accounts for all of these phenomena by the rotation of the earth.

As the earth revolves from west to east the envelope of air surrounding it shares its motion, but may in addition have a motion of its own. If we imagine a particle of air moving from some point in north latitude toward the equator, it is clear that the particle will in the beginning have an eastward velocity equal to that of the spot from which it starts; but that as it moves toward the equator it will find the earth beneath it turning more and more rapidly (in linear velocity) and, failing to take up entirely this increased velocity, will lag behind and manifest itself as a wind from the northward and eastward. That is to say, it will be continually diverted to the right as it moves southward.

A particle of air moving from the equator northward, will, on the other hand, start out with the eastward velocity of the earth at the equator, and will thus outrun the more slowly moving surface over which it passes as it travels northward. Thus this particle will also be diverted to the right. And so with every particle of air which we may suppose to be moving in the northern hemisphere along any line except one due east and west. To some extent it will have a tendency to turn to the right. In Plate **114** are shown a number of such particles moving toward a common center of low barometric pressure, and forming inevitably a left-handed swirl (Fig. 2).

Similar considerations will make it clear why the winds flowing outward from a "high" revolve in the opposite direction, and why all these conditions are reversed in southern latitudes.

The following simple law, first enunciated by Buys-Ballot, puts in convenient form the relation between pressure and wind circulation.

When facing the wind, in the northern hemisphere the pressure is lower on your right hand and higher on your left; and conversely, in the southern hemisphere, it is higher on the right and lower on the left. This rule, it should be noted, applies to winds in general; not alone to storms.

Observations of winds, temperatures and pressures extending over a long period of years indicate the existence in the polar regions of an area of low barometer about which the winds circulate with the characteristic cyclonic direction, giving rise to the "Westerlies" or "Passage Winds" of the regions north and south of the Trades.

It is clear, of course, that this condition cannot be due to the causes which produce the low pressure in the equatorial region; and the commonly accepted theory accounts for it as a result of the centrifugal force acting upon the mass of the atmosphere as it is whirled about by the earth's rotation on its axis. Whether this be the true explanation or not, there is abundant evidence that the pressure is low at the poles as well as at the equator and that there exists an intermediate belt of generally high pressure in the neighborhood of 30° of latitude, from which the air tends to draw—on the one hand toward the equator, on the other toward the poles. This belt of high pressure, of comparative calms, and of baffling winds, while not always well marked over the continents, can be clearly traced across the ocean, where it is well known to navigators under the name of the "Horse Latitudes."

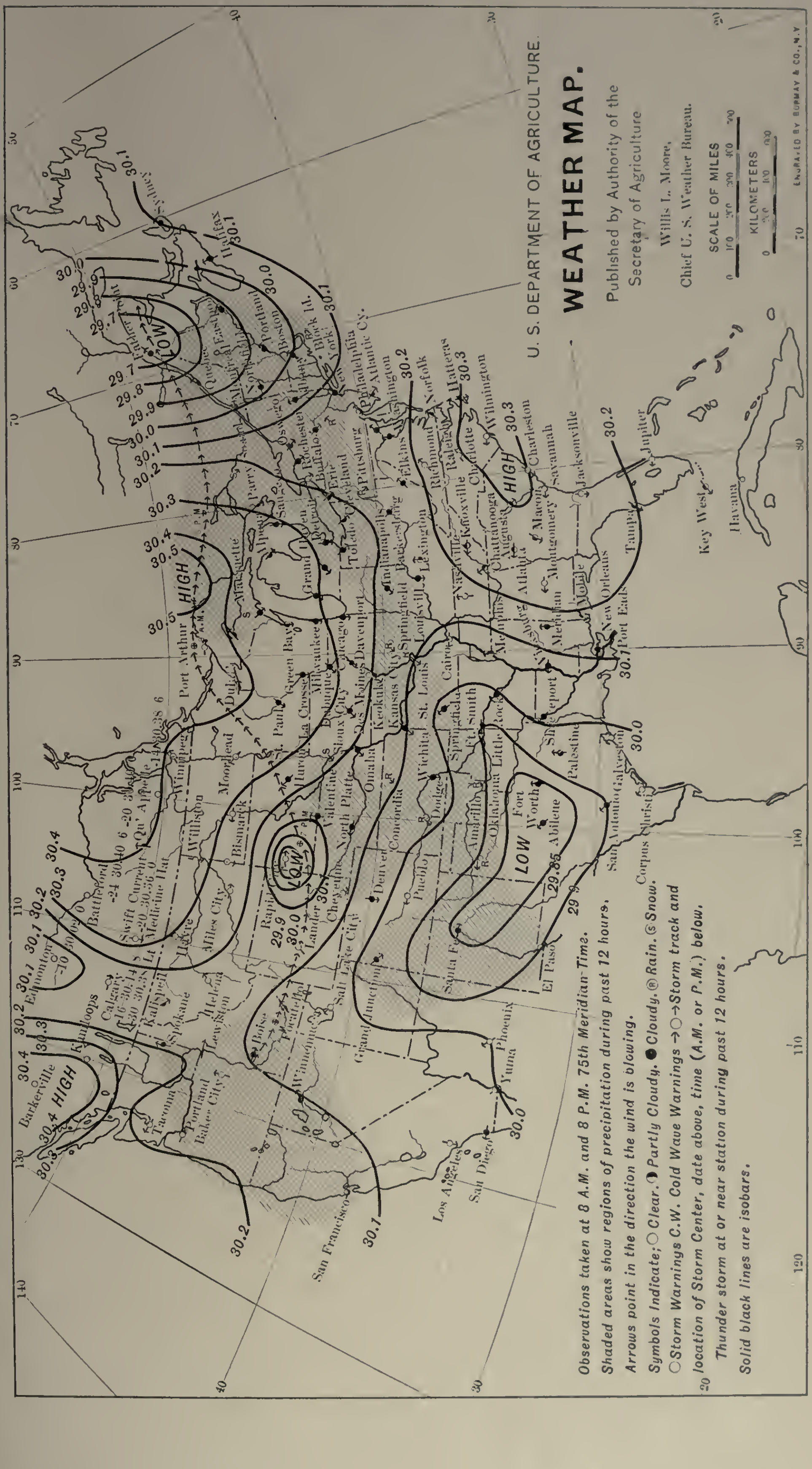
The winds blowing about and toward the poles take up the characteristic motion which has been explained, and there results, in latitudes above (approximately) 35° north and south, a steady flow of the atmosphere toward the east. At the earth's surface, this flow is often delayed, arrested, and turned back to the westward by local and temporary causes, but in the upper regions of the atmosphere it continues without interruption though not with unvarying velocity.

In this continued eastward movement of the air is to be found the key to the fluctuations of weather which (for example) sweep across the continent of North America and the North Atlantic Ocean; as well as the possibility of predicting from day to day approximately what weather may be expected at any given place. Disturbances of the atmosphere—highs and lows, with the weather features which have been described as characterizing them—sweep across the continent in a regular procession, following paths which may vary considerably, but are always toward the eastward. These disturbances may originate within the limits of the continent or may enter it from the Pacific; but they invariably leave it by the Atlantic sea-board and usually by way of the New England coast or the Gulf of St. Lawrence (see Plate **114**). An examination of the weather maps published by the United States Government for several successive days gives an interesting view of this progression of varying weather characteristics toward the east, and makes clear in a general way the laws upon which weather forecasting is based. Plate **115** shows a map of this kind. The corresponding map for the following day would show the successive highs and lows as having moved to the eastward, carrying with them their characteristic features of wind-circulation, temperature, cloud or clear sky, precipitation, etc.

The following description of the daily weather map is from a leaflet published by the Weather Bureau:

> This map presents an outline of the United States and Canada, showing the stations where weather observations are taken daily at 8 A. M. and 8 P. M., seventy-fifth meridian time. These observations consist of readings of the barometer, thermometer (dry and wet), direction and velocity of wind, state of weather, amount, kind and direction of the clouds, and amount of rain or snow; they are telegraphed to Washington and to many of the Weather Bureau stations throughout the country for publication on the maps. Solid lines, called isobars, are drawn through points having the same atmospheric pressure; a separate line being drawn for each difference of one-tenth of an inch in the height of the barometer. Dotted lines, called isotherms, connecting places having the same temperature, are drawn for each ten degrees of the thermometer. Heavy dotted lines, inclosing areas where a decided change in temperature has occurred within the last twenty-four hours, are sometimes added. The direction of the wind is indicated by an arrow flying with the wind, or opposite to the ordinary vane. The state of weather—whether clear, partly cloudy, cloudy, raining, or snowing—is indicated by the circular symbol. Shaded areas, when used, show where rain or snow has fallen since the last observation.
>
> The general movement of storms in the United States is from west to east, similar to a series of atmospheric waves, of which the crests are designated on the map " Highs," and the troughs or depressions " Lows." These alternating Highs and Lows have an average easterly movement of about 600 miles per day.
>
> High winds, with rain or snow, usually precede the Low area, often extending to a distance of 600 miles to the eastward of the center of the storm. In advance of the Low the winds are generally southerly, and consequently bring high temperature. When the center of the Low passes to the east of a place, the wind at once shifts to the west or northwest, bringing lower temperature. The temperature on a given parallel west of the Low may be reasonably looked for on the same parallel to the east when the Low has passed, and frost will occur along and north of an isotherm of about 40°, if the night is clear and there is but little

Plate No 115.


U. S. DEPARTMENT OF AGRICULTURE.
WEATHER MAP.
Published by Authority of the Secretary of Agriculture
Willis L. Moore,
Chief U. S. Weather Bureau.
SCALE OF MILES
KILOMETERS
ENGRAVED BY BORMAY & CO., N.Y.
Observations taken at 8 A.M. and 8 P.M. 75th Meridian Time.
Shaded areas show regions of precipitation during past 12 hours.
Arrows point in the direction the wind is blowing.
Symbols Indicate; ○ Clear. ◐ Partly Cloudy. ● Cloudy. ® Rain. Ⓢ Snow.
○ Storm Warnings C.W. Cold Wave Warnings →○→ Storm track and location of Storm Center, date above, time (A.M. or P.M.) below.
Thunder storm at or near station during past 12 hours.
Solid black lines are isobars.
HIGH
LOW
HIGH
LOW
HIGH
LOW
HIGH

wind. Following the Low usually comes an area of High, bringing sunshiny weather, which in its turn is followed by another Low.

By bearing in mind a few general rules as to the direction and rate of movement of the Low and High, with the blowing of the wind from the High toward the Low, and studying the map carefully, coming weather changes may frequently be foreseen. The centers of Lows do not, as a rule, move across isotherms, but follow their general direction. Areas of low pressure frequently move to the south of east from the Rocky Mountains to the Mississippi and then change direction to the north of east over the eastern half of the country. Storms in the Gulf of Mexico occasionally move to the west or north of west, but after reaching the coast, they generally change direction and move to the northeastward. High areas move to the southeast and are usually attended by fair and cool or cold weather. A cold wave is always accompanied by a High.

The cloud and rain area in front of a Low is generally about the size of the latter and oval, with the west side touching the center of the Low in advance of which it progresses.

When the isotherms run nearly east and west no decided change in temperature will occur. If the isotherms directly west of a place incline from northwest to southeast, it will be warmer; if from northeast to southwest it will be colder. Southerly to easterly winds prevail west of a nearly north and south line passing through the middle of a High, also east of a like line passing through the middle of a Low. Northerly to westerly winds occur west of a nearly north and south line passing through the middle of a Low and also east of a similar one through the middle of a High.

An absence of decided waves of High or troughs of Low pressure indicates a continuance of existing weather which will last till later maps show a change, usually first appearing in the west.

The temperature of the air as published on the map is observed with a dry-bulb thermometer, and also with a wet-bulb thermometer—that is, one whose bulb is covered with a moist wrapping. The evaporation from the wetter surface, if the air is not saturated with moisture, is more rapid than from the dry bulb, in proportion to the relative amount of aqueous vapor in the air. The difference of temperature between the readings of these two thermometers suffices to compute the relative humidity of the atmosphere. The temperature of the wet bulb is lower than that of the air as given by the dry-bulb thermometer, on account of the evaporation from its bulb. The wet-bulb temperature is sometimes called the sensible temperature, because the sensation of heat on the skin agrees more closely with its indications than with those of the dry thermometer.

A study of these charts, with their succession of highs and lows will make it clear why bad weather in the eastern part of the United States almost invariably begins with an easterly wind and clears with a cold northwester.

It should be noted that highs and lows must of necessity accompany each other, since the inward draft of air in a low implies the existence of a neighboring high, from which the wind flows outward. The relation between the two is shown in Fig. 1, Plate **113**.

After the circulation of the winds, the most interesting and important features in connection with weather changes are the phenomena of precipitation, and temperature changes. It has already been explained why there is a tendency toward precipitation in the upward draft of a low; but it is found that in the case of the lows moving to the eastward across the United States, the precipitation is much greater along the forward part of the storm and in its eastern and southern quadrants than to the northward and westward. The explanation of this is that the winds of the eastern and southern quadrants are largely drawn from the warm regions of the southern states and from the Gulf of Mexico, and are charged with moisture which they deposit as they sweep northward and rise at the same time into the cooler regions of the upper atmosphere. This explains why, in north latitudes, rain comes with an easterly or southerly wind.

The winds of the northern and western quadrants are relatively dry and cold.

The same explanation suffices in a general way to account for the succession of warm and cool waves which are the more or less marked accompaniments of the *highs* and *lows*. It has already been explained that a *low* is, in its essential nature, an area of upward tending warm air, while a *high* is an area of downward-flowing cold air. But an inspection of our weather maps will show that in addition to this we have, on the forward side of an advancing low, a southerly or southeasterly wind, drawing up from the warm regions of the tropics; while the front of a high is made up of northerly winds sweeping down from British America.

Where a low originates in the tropics, it moves at first westward instead of eastward, being carried along by the general movement of the atmosphere. At the same time it works more or less toward the north (or south) and in the end becomes involved in the eastward current above described. Under the influence of this current it recurves and sweeps off to the eastward, taking its place in the procession of highs and lows which have already been discussed.

The laws of atmospheric circulation which have been outlined above are subject to many exceptions and modifications, due to the irregular distribution of land and water and to other circumstances which break up the symmetry of an ideal globe. The predominance of land in the northern as compared with the southern hemisphere is the most important factor in modifying the general law.

Of the modifications thus introduced, the most marked and important is the enormous change over the continent of Asia from winter to summer, causing the phenomenon known as the reversal of the monsoons;—a phenomenon which is of vital importance to half the inhabitants of the globe.

This extensive continental area is excessively heated during the summer months and the air in contact with its surface becomes heated and rises, creating an upward draft of sufficient power to overcome the effect of the similar draft in the equatorial belt and to turn back the N.E. trade wind on its track, converting it into a S.W. "monsoon" which blows steadily and often violently, for several months of the year; after which, the continent having cooled down sufficiently to restore the normal balance of pressures, the trade wind again sets in;—under the local name of the N.E. monsoon.

These phenomena are strictly analogous to the alternation of land and sea breezes which characterize the summer climate of nearly all sea coasts. The land becomes abnormally heated during the day, the air above it rises, and a breeze draws in from seaward which continues until toward evening. During the night the land radiates its heat more rapidly than the water, the relative temperature and barometric conditions are reversed, and the land-breeze springs up and blows throughout the night.

Reverting once more to Plate **112**, attention may be called to the marked contrast between winter and summer conditions throughout the earth's surface, as regards not only temperatures, but pressures and wind-circulation as well.

It will be noted that the winter storms of the North Atlantic are not usually tropical in their origin, but begin, as a rule, in the region of westerly winds and sweep across, usually well to the northward, following the general course of these winds. They are, in fact, in many if not most instances, identical with storms which have already swept across the North American continent; and in some cases it is possible to trace their history far back over the Pacific.

If it were possible to add still more data to Plate **112**, it would be of interest to show the average amount of cloud, winter and summer; the precipitation in the form of rain or snow; the regions of maximum and minimum departure from normal temperature and pressure, and the amount of such departure; and the average daily range of the thermometer and barometer, together with the daily barometric tides. Were such data added it would be seen that the cloudy rainy regions are those of the equatorial calm belt and the high latitudes of the temperate zones, where low pressures indicate ascending currents; and that the tolerably clear regions are the belts of high pressure along the 30th parallels, with more cloudiness over the oceans and less over the continents, but entirely clear skies over the great deserts and in the lee of mountain ranges only. The rainfall data would show clearly the influence of prevailing winds in carrying moisture from the oceans to the continents, sometimes far inland over level land, sometimes only as far as a mountain range that chills and precipitates the aqueous vapor. The winds carry the temperatures, too, of the oceans they traverse, and thus modify weather and climate, with a tendency toward warmth rather than cold, inasmuch as the condensation of the vapor which they carry sets free large quantities of latent heat. Where storm tracks are numerous the rainfall is heavy; witness the case of cyclones which carry moisture with them from the Bay of Bengal to the foothills of the Himalayas producing rainfalls of 30 and even 40 inches a day, which may be contrasted with an average daily rainfall of 1 inch in most parts of the United States. The great variations from normal temperature and pressure that occur in the stormy high latitudes of the temperate zones contrast forcibly with the uniformity and regularity within the tropics. The daily range of the thermometer depends on whether it is winter or summer, clear or cloudy; that of the barometer, on the position of the region relative to the tracks and number of passing cyclones and anti-cyclones. The barometric tides, slight in themselves but moving in the equatorial regions with the regularity of clockwork, with daily forenoon and evening maxima and early morning and evening minima, are often obscured in higher latitudes by the far greater changes due to passing storms, and are modified a little everywhere by the effect of continents close by. All of these phenomena, so closely inter-related, may be studied in connection with the fundamental data represented graphically in Plate **112**.

THE BAROMETER.

It will be evident from what precedes, that the barometer is beyond comparison the most important of the instruments available for forecasting weather, and that it is deserving of much more exact attention than it commonly receives on shipboard. It should be carefully placed where it will hang vertically and be subject to a temperature not widely different from that of the outside air. A thermometer should be attached to it or placed near it, and the temperature indicated by this thermometer entered with every reading of the barometer recorded. Comparison should be made from time to time with a standard barometer in ports where such an instrument can be found. For this comparison it is not necessary to bring the instruments together, but only to get practically simultaneous readings and to apply the proper corrections for temperature. A comparison carefully made, with the proper corrections, gives an instrumental error which may be checked from time to time as opportunity permits, and makes it possible to compare the readings of the instrument with data published on Weather Charts and in Sailing Directions, as well as to furnish additional reliable data for publications of that kind.

It will add to one's interest in keeping a good barometric log to know that others can easily check its accuracy, both at once and years hence. For instance, suppose you make a voyage from New York to Liverpool, thence to Hamburg, Cape Town, Melbourne, and Yokohama. Whenever you pass within a few miles of another vessel, or of any port or coast of a country where daily weather maps are published (such as the United States, England, Germany, France, Cape Colony, Australia, and Japan), a comparison of your log with other good logs, or with the published observations that are available in the libraries of government and other offices all over the world, will give any one that chooses to make it, a perfect check on your record. If it stands the test, it becomes a good check on other logs and valuable for study. Very few areноids will stand this rigid and long-continued test of reliability, however useful they may be in showing changes of pressure from time to time in practical use at sea.

To draw conclusions from the reading of the barometer we must know the normal pressure of the place and time of observation. These are shown for mid-winter and mid-summer in most parts of the world on Plate **112**, and should be given for all places and seasons in Sailing Directions. The importance of this point is indicated by the fact that a corrected pressure of 29.40 is normal for high southern latitudes, but very low for corresponding latitudes north.

The normal pressure at any given place may be expected to show the regular daily fluctuation or "barometric tide," already referred to, and which is entirely independent of variations connected with the weather. This fluctuation is greatest in the tropics and disappears in very high latitudes both north and south. The extreme daily range in the tropics is in the neighborhood of $\frac{1}{10}$ of an inch. The maxima occur about 10 o'clock, the minima about 4 o'clock, A. M., and P. M. Apart from the daily tides, the variations in barometric pressure are slight within the tropics, while in high latitudes they are very marked.

CLOUDS.

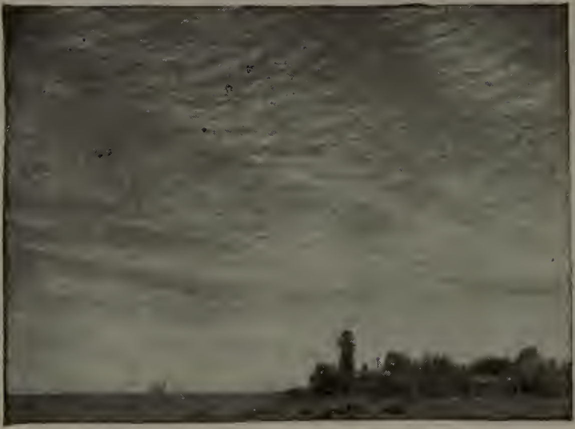
The relation of cloud-forms of various kinds to weather, either existing or in prospect, is a matter of the greatest importance; but unfortunately our knowledge upon this subject is still very limited. The usual classification of cloud-forms is shown in Plate **116**, and the following notes give in condensed shape about all that is known with regard to their significance.

DESCRIPTION OF CLOUD-FORMS (PLATE 116).

The following cloud-forms are arranged according to a general descending scale of altitude, observation having shown that there are five main cloud levels; viz.: cirrus (highest), cirro-cumulus, alto-cumulus, cumulus, and stratus (lowest).

1. **Cirrus (Ci.)**.—Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white color, sometimes arranged in belts which cross a portion of the sky in great circles, and, by an effect of perspective, converge toward one or two opposite points of the horizon. (The Ci.-S. and the Ci.-Cu. often contribute to the formation of these belts). The height of cirrus is from 5 to 6 miles.

Plat



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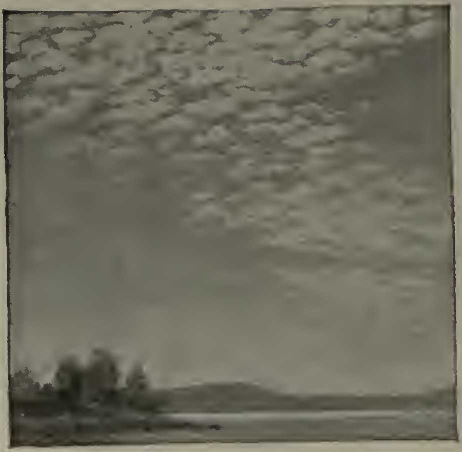

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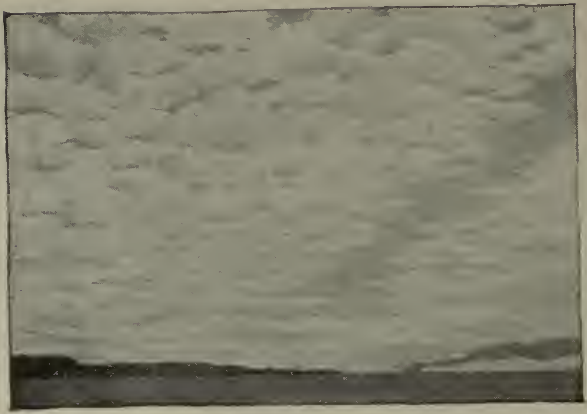

4

PRINCIPAL FORMS

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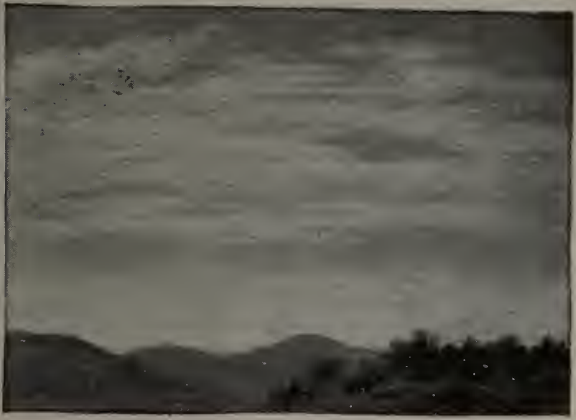
116.



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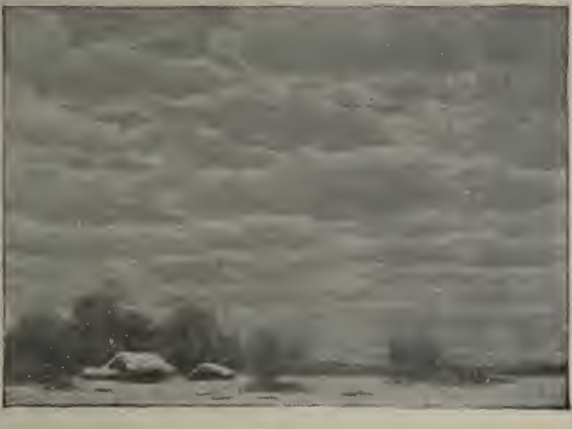


6

JDS (AFTER KÖPPEN).

2. **Cirro-Stratus (Ci.-S.).**—A thin, whitish sheet, at times completely covering the sky and only giving it a whitish appearance (it is then sometimes called cirronebula), or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon. Average height about 5½ miles.

3. **Cirro-Cumulus (Ci.-Cu.).**—Small globular masses, or white flakes without shadows, or having very slight shadows, arranged in groups and often in lines. Height about 4 miles.

4. **Alto-Cumulus (A.-Cu.).**—Rather large globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. The detached masses are generally larger and more compact (changing to S.-Cu.) at the center of the group; at the margin they form into finer flakes (changing to Ci.-Cu.). They often spread themselves out in lines in one or two directions.

5. **Alto-Stratus (A.-S.).**—A thick sheet of a gray or bluish color, showing a brilliant patch in the neighborhood of the sun or moon, and which, without causing halos, may give rise to coronæ. This form goes through all the changes like the Cirro-stratus, but, by measurements made at Upsala, its altitude is one-half less. Height about 3 miles.

6. **Strato-Cumulus (S.-Cu.).**—Large globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter, and occasionally giving it a wavy appearance. The layer of Strato-cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance, and also because it does not bring rain. Average height about 1 mile.

7. **Nimbus (N.).**—Rain clouds.—A thick layer of dark clouds, without shape and with ragged edges, from which continued rain or snow generally falls. Through the openings of these clouds an upper layer of Cirro-stratus or Alto-stratus may almost invariably be seen. If the layer of Nimbus separates into shreds, or if small loose clouds are visible floating at a low level, underneath a large nimbus, they may be described as Fracto-nimbus (Fr.-N.), "Scud" of sailors.

8. **Cumulus (Cu.).**—Wool-pack clouds.—Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal. These clouds appear to be formed by a diurnal ascensional movement which is almost always observable. When the cloud is opposite the sun, the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, these clouds give deep shadows; when, on the contrary, the clouds are on the same side as the sun, they appear dark, with bright edges.

The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. These may be distinguished by the name of Fracto-cumulus (Fr.-Cu.).

9. **Cumulo-Nimbus (Cu.-N.).**—The Thunder-cloud; Shower-cloud.—Heavy masses of clouds rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above

(" false Cirrus "), and underneath, a mass of cloud similar to " Nimbus." From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail). Sometimes the upper edges have the compact form of Cumulus, forming into massive peaks round which the delicate " false Cirrus " floats, and sometimes the edges themselves separate into a fringe of filaments similar to that of the Cirrus cloud. This last form is particularly common in spring showers.

The front of thunderclouds of wide extent frequently presents the form of a large bow spread over a portion of the sky which is uniformly brighter in color.

10. **Stratus (S.).**—A horizontal sheet of lifted Fog.—When this sheet is broken up into irregular shreds by the wind, or by the summits of mountains, it may be distinguished by the name of Fracto-stratus (Fr.-S.).

Note.—The attention of mariners is especially called to the value of observations of cirrus, as this form of cloud is often closely connected with barometric depressions. If the cirrus occurs in radiating bands crossing the sky, the point of convergence of these bands should be noted; if in the form of a cloud bank, or sheet, upon the horizon, the center, or point of greatest density of this bank; as this point will sometimes serve to indicate in a general manner the direction of the center of any cyclonic disturbance.

§ II. THE LAW OF STORMS.

The general features of this law have been enunciated in the preceding pages; for the storms with which the law deals (in its special application to Seamanship), are simply cyclones or *lows* like those already described, but with all their characteristic features intensified and concentrated within comparatively narrow limits.

These storms, variously known as " Cyclones," " Typhoons," " Tropical Hurricanes," etc., have their origin over the ocean and on the border-land between the equatorial hot-belt and the trade-wind region, where unsettled conditions would naturally be expected to prevail. Many theories have been put forward to explain their origin, but none which is entirely satisfactory. The generally accepted theory connects the development of the disturbance with the existence, as a preliminary, of excessively sultry, rainy, and squally conditions in the lower layers of the atmosphere, and the coincidence in the upper layers, of temperatures lower than those due to the normal decrease of temperature with the altitude. This is evidently a condition of unstable equilibrium and sooner or later results in the formation of ascending currents and a general overturning of the atmosphere, with a sudden and violent inrush of air from all the

Plate No. 117.

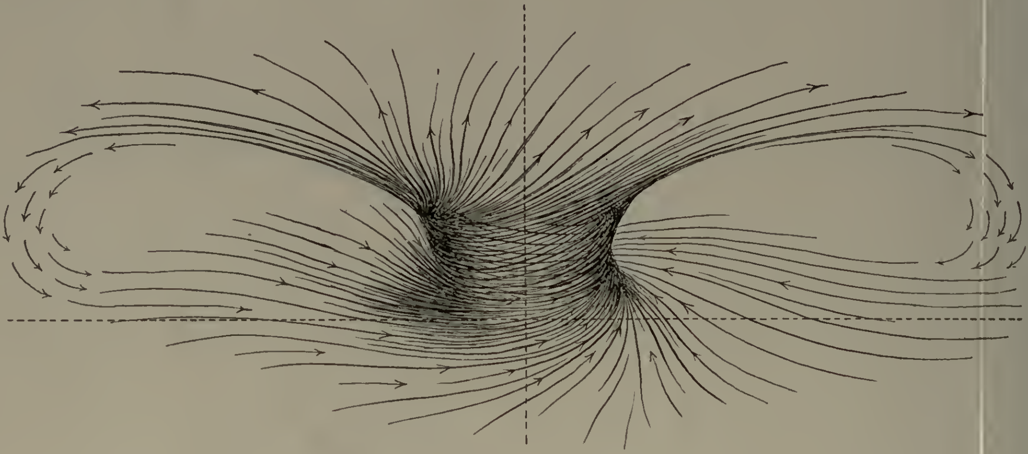


FIG. 1. WIND CIRCULATION IN HURRICANE, NORTHERN HEMISPHERE.

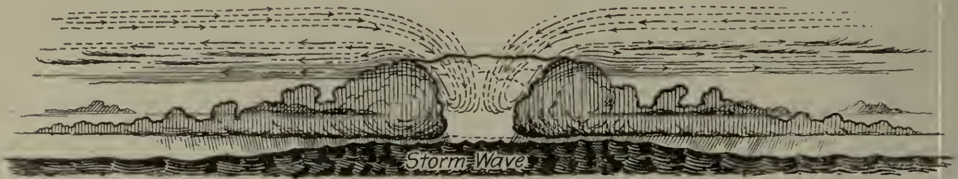


FIG. 2.
CROSS-SECTION OF HURRICANE, SHOWING CLOUD-BANK, CENTRAL CALM AND STORM-WAVE.

surrounding regions. This action, once commenced, is increased in intensity by the formation of clouds and rain in the ascending air, resulting in the liberation of heat, which acts to increase still further the violence of the upward- and inward-rushing currents. The air flowing in takes up the characteristic cyclonic rotation which has already been described and explained, and the hurricane vortex is established, with extremely low pressure and a clear calm space of small diameter at the center. In this vortex and the surrounding whirl there are different degrees of rotation to the different layers of the atmosphere, beginning at the base with an inward spiral which diverges by perhaps two points from a circle (at a distance from the center) and ending at the top—many miles above the base—with currents radiating almost directly outward. An attempt is made to indicate this circulation in Plate **117**. The successive layers of air are marked by different cloud-forms resulting from the special conditions to which the moisture in the swirl finds itself subjected. The lowest layer above that at the surface is marked by low fast-flying scud, which is observed to move in what is practically a circle; above this and diverging slightly outward is a layer of cumulus, and above this come in succession alto-stratus, cirro-cumulus, and in the rare, cool atmosphere six miles and more above the surface, the long feathery plumes of cirrus, radiating almost directly outward. Naturally, these successive layers of cloud are not distinguishable by an observer actually involved in the storm, as his view is bounded by the heavy scud over his head; but they can be more or less clearly made out from a distance, the cirrus clouds in particular being distinguishable above the heavy bank beneath, and indicating by the point from which they radiate, the bearing of the center of the storm. Great activity of movement in the upper clouds, observed while the center is still distant, indicates a storm of great severity. If the cirrus plumes are faint, fading gradually behind the slowly thickening veil, the storm is an old one of large area; if they are of snowy whiteness, projected against a clear blue sky, it is young and of small area, but of great intensity. The general direction of translation is at first toward the west, but with a slight tendency away from the equator which becomes more and more marked, until the storm sweeps around altogether, and, in the region of westerly winds, moves off to the eastward. The velocity of translation varies from a few miles an hour to as much as twenty-five or thirty miles, being greatly affected by the barometric pressures prevailing *in the regions towards which it is advancing.* Thus a storm advancing toward the Atlantic coast of the United States may find prevailing over the continent and the coasts, an area of very high barometer against which it comes up as against an elastic but impenetrable barrier. It may thus be slowed down and held back, or, as frequently occurs, shunted off to one side and entirely changed in direction. A striking example of this kind is shown on Plate **118**, where a cyclone which was apparently marked out for a track along the Atlantic coast found its path blocked by a "High" and was finally driven off onto the west Gulf Coast, where it entirely destroyed the city of Galveston. This effect is similar to that of the fixed area of permanent high barometer shown on Plate **112** as overhanging the North Atlantic Ocean during the summer months. The storms of this season follow around the outside limits of this area, the existence of which undoubtedly counts for much in determining their course. Their track, in fact, is usually along a trough of low pressure between two highs, one overhanging the ocean, the other the land. Other factors of importance in determining the track of the storms, are the general circulation of the atmosphere, with which they tend to move along, and the existence of such ocean currents as the Gulf Stream in the North Atlantic and the Japanese Current in the North Pacific; the excessive evaporation over these currents tending to create a trough of low pressure such as has been referred to above. The track of such a storm in the North Atlantic is shown in Plate **119**, in which are brought out many points of interest and importance in connection with its progress and development. It will be noted that the shape of the storm, far from being a circle, is a decided ellipse, with a well-marked trough of low pressure along its major axis. In the early stages of its progress the storm is of small area but great intensity. As it progresses, it spreads out and, usually, loses something of its violence; (as is indicated by the increasing distance between the isobars), and in the end sweeps across the North Atlantic as a southeasterly gale with a northwester following close upon it. Taken as a whole, the storm here shown is a summer type, but in the final part of its path it represents also the winter storms of the North Atlantic,

Plate No. 118.

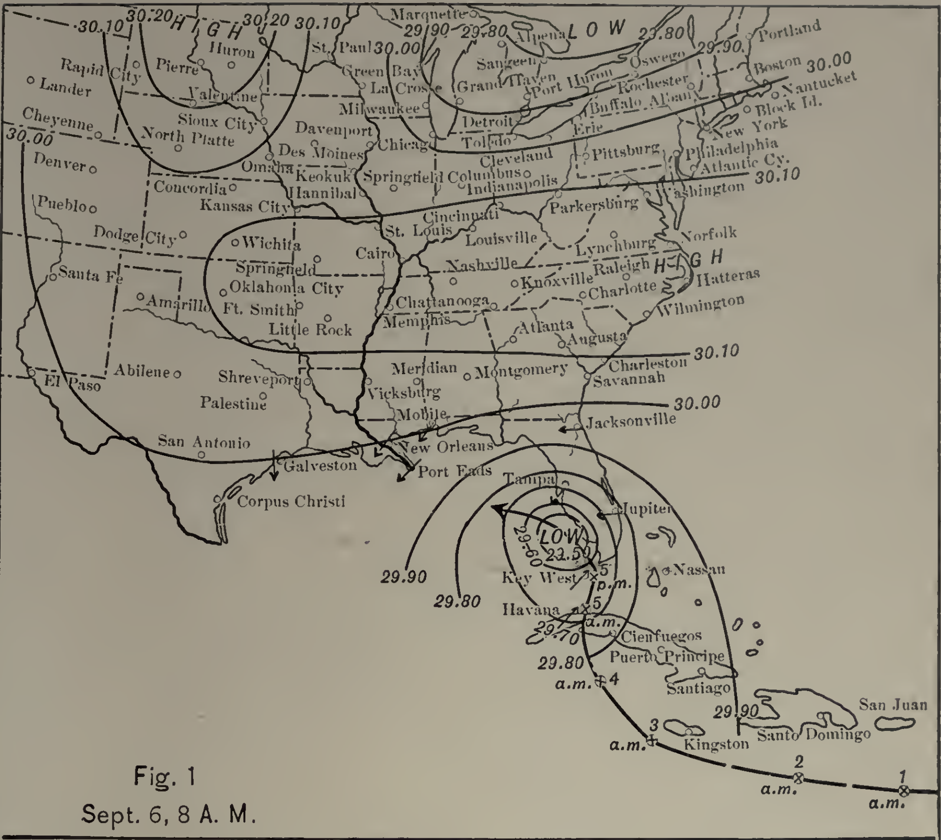


Fig. 1
Sept. 6, 8 A. M.

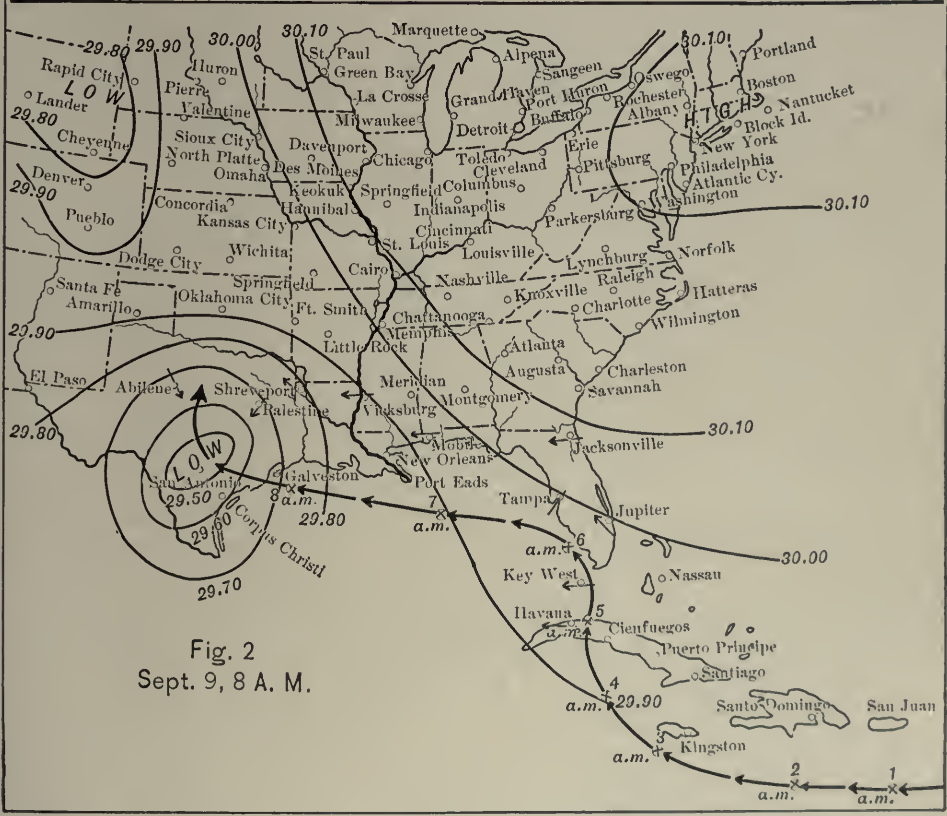


Fig. 2
Sept. 9, 8 A. M.

GALVESTON HURRICANE SEPTEMBER 1900.

which are none the less cyclonic because they do not originate in the tropics.

Strictly speaking, we should consider this chart to represent, not the progress of a single storm on a number of successive days, but a number of storms existing at the same time. This is not an impossible condition of affairs, although it would of course be an unusual one. For our present purpose, however, we may imagine that the "high" which is shown as hanging over the western part of the area included by the chart has remained stationary for several days (a phenomenon which is not uncommon) and that the storm has made its way through the trough between this high and the permanent anti-cyclone to the eastward.

The chart illustrates the conditions of weather characterizing each portion of the storm, and can be made to show the changes which would be encountered by a vessel passing through the storm along any given line, or lying to and allowing the storm to pass over her. An inspection of this chart will explain most of the characteristic features of bad weather in the North Atlantic; showing why gales commonly begin with the wind at east or southeast and end with it at N.W.; and why the change from one quarter to the other often comes in a sudden shift with violent squalls. This shift is due to the passage of the trough of low pressure into which the originally circular center has been stretched out. (Compare with Plate **113**.)

Among the weather proverbs most firmly believed in by sea-faring men is the one which insists that good weather is not to be expected after a storm in the northern hemisphere if the wind shifts to the left, or *backs*. It will be clear from what precedes, that this is true only for observers in the right-hand semi-circle of the storm. In this semi-circle, as has been shown, the wind shifts to the right as the storm passes, and goes to Northwest by way of South, Southwest and West. In the left-hand semi-circle, on the other hand, the northwest weather of the clear anti-cyclone follows a shift to the left, through Northeast and North.

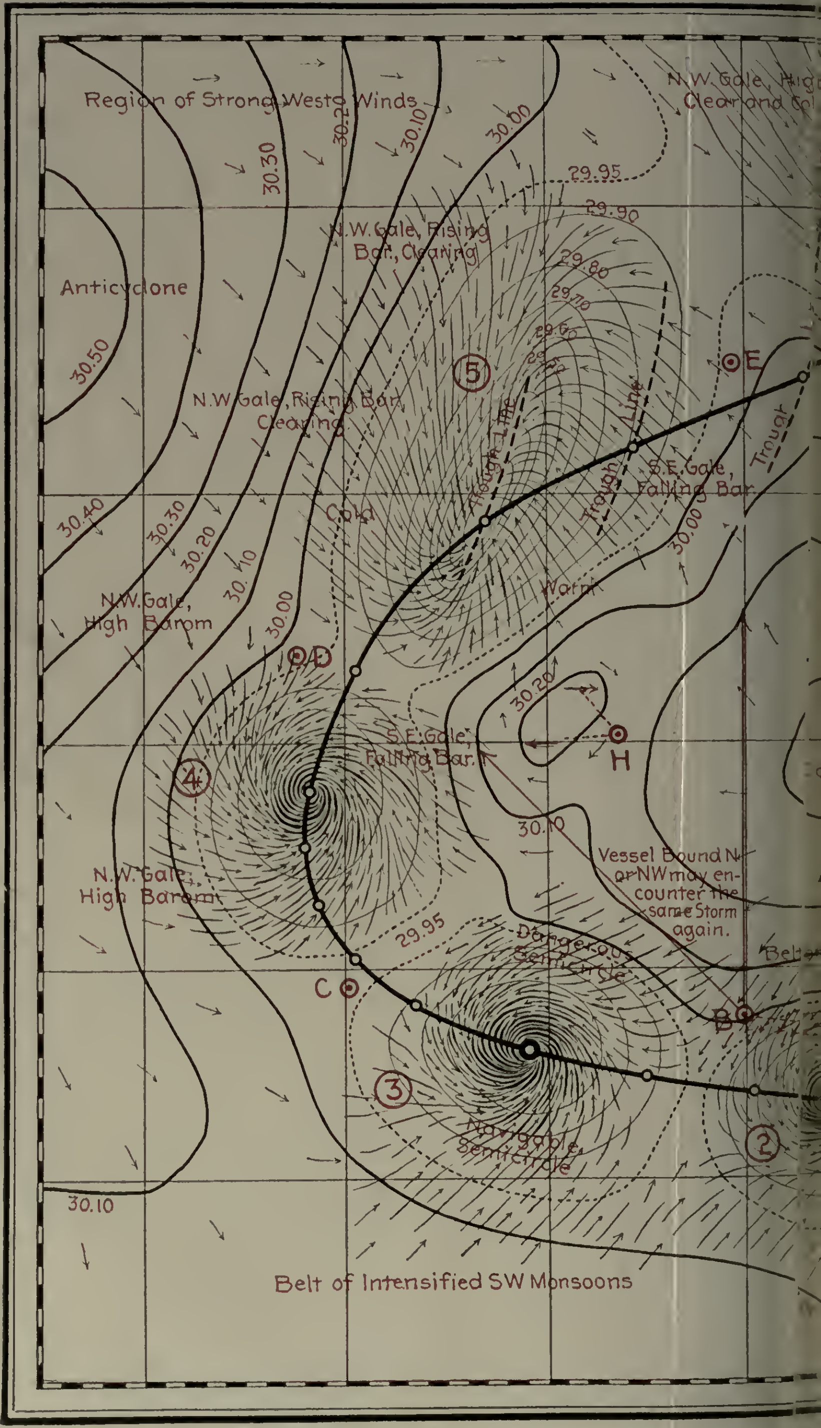
It happens, however, that the Atlantic and Gulf Coasts of the United States, and the greater part of Europe (including England) lie to the south and east of the average path of the storms to which these regions are subject; and the same is true of the ordinary tracks of vessels in the North Atlantic. Thus it happens that with regard to a very large majority of the storms moving over these regions, observers find themselves in the right-hand semi-circle; and do, as a matter of fact, get their clearing weather by a shift of the wind to the right. This is not true of tropical hurricanes, but it must be remembered that these are few in number in comparison with the storms which originate in higher latitudes. (See Plate 121.)

The velocity of translation of storms varies within wide limits and it is very unsafe to assume even an approximate value for it in any given case. It may be said, however, that the *average* velocity per hour within the tropics is between 15 and 20 knots; that as the storms turn toward the north (or south) they slow down, the average for this part of the path being from 5 to 6 knots; and that as they recurve and start off to the eastward, the velocity usually increases, the average for this part of the track being something like 25 knots. The maximum velocity that has been observed does not much exceed 30 knots. The velocity of rotation varies from 50 to 100 miles an hour and perhaps even more than this. It is evident that on one side of the track, or in one semi-circle of the storm, the velocity of translation will be added to that of rotation, while in the other semi-circle it will be subtracted. This is one of the most important reasons for regarding one semi-circle as "dangerous" and the other as "manageable." Other reasons are that this is the side toward which the storm-track curves, and that on this side the winds and currents tend to set the vessel toward the front of the storm-center.

Rules are sometimes laid down as to the latitude of recurving of storms at different seasons of the year; but such rules are even more dangerous than those which deal with the velocity of translation. The storm tracks plotted on Plate **121** give all the data that are available on this subject, and indicate clearly enough that no rule can be laid down which will not be subject to so many exceptions as to render it altogether valueless.

Plate **117** illustrates on an exaggerated vertical sectional scale the cloud formation, wind circulation and storm wave of a hurricane. The mountainous central mass of cloud, composed of heavy nimbus below and towering leaden cumulus above, often maintains a remarkable fixity of bearing, which, together with its solid rugged appearance, makes it look like distant land. Such a cloud-bank was once visible from Trinidad, Cuba, for five entire days.

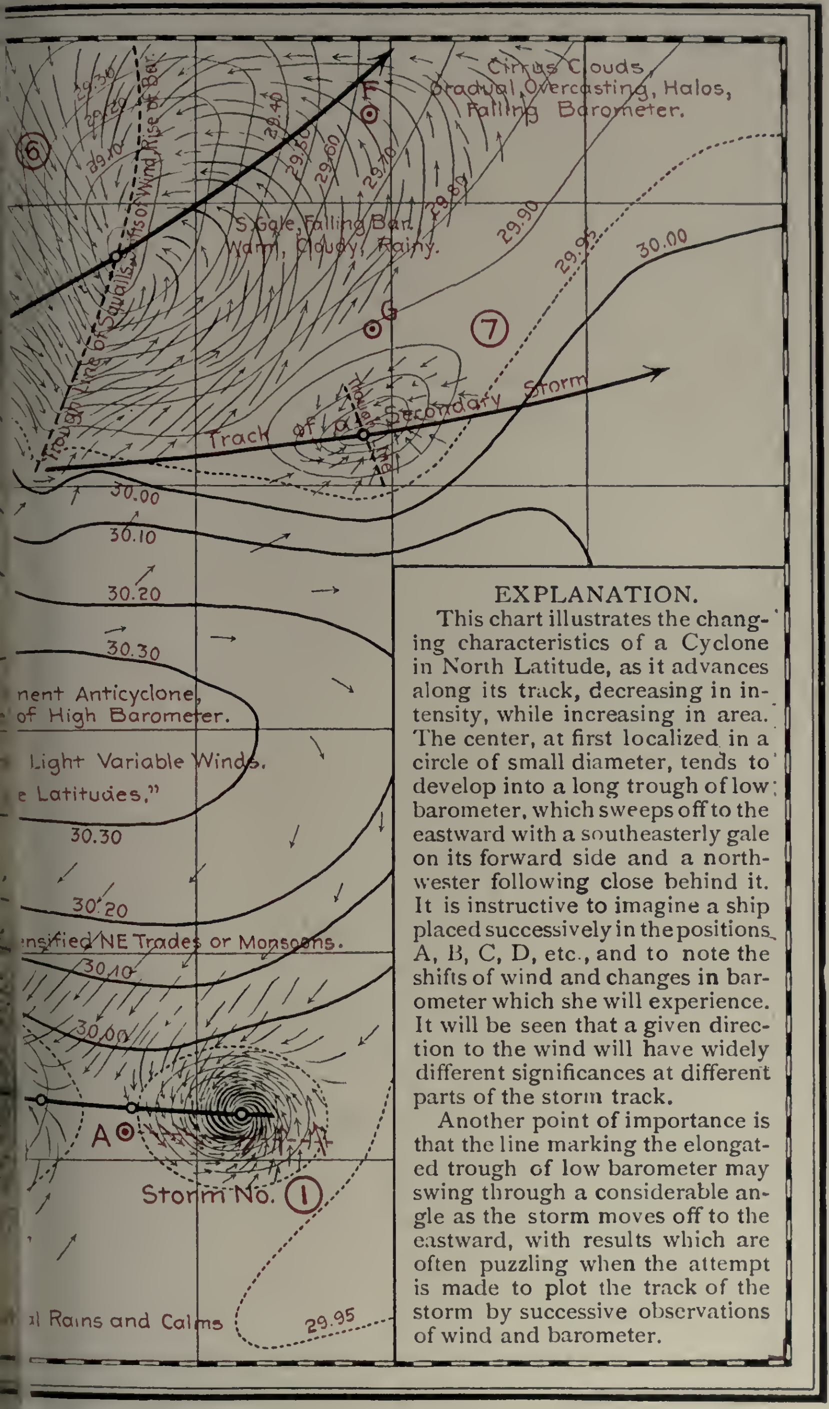
The storm wave, or general rise of the level of the sea near the center, due to the inrushing winds and low pressure, moves along with the storm until perhaps precipitated in a great flood upon islands and coasts in its path. Such a flood, the night of



OCEAN CYCLONES AND ANTI-CYL

A Diagram of Typical Wind Circulation from A
North of the Equator, and th

119.


Cirrus Clouds, Gradual Overcasting, Halos, Falling Barometer.
S. Gale, Falling Bar. Warm, Cloudy, Rainy.
Trough Line of Squalls, Shifts of Wind, Rise of Bar.
Track of a Secondary Storm
⑥
⑦
F
G
A
Storm No. ①
29.30
29.20
29.10
29.40
29.50
29.60
29.70
29.80
29.90
29.95
30.00
30.10
30.20
30.30
30.30
30.20
30.10
30.00
29.95
nent Anticyclone, of High Barometer.
Light Variable Winds.
e Latitudes,"
nsified NE Trades or Monsoons.
l Rains and Calms

EXPLANATION.

This chart illustrates the changing characteristics of a Cyclone in North Latitude, as it advances along its track, decreasing in intensity, while increasing in area. The center, at first localized in a circle of small diameter, tends to develop into a long trough of low barometer, which sweeps off to the eastward with a southeasterly gale on its forward side and a northwester following close behind it. It is instructive to imagine a ship placed successively in the positions A, B, C, D, etc., and to note the shifts of wind and changes in barometer which she will experience. It will be seen that a given direction to the wind will have widely different significances at different parts of the storm track.

Another point of importance is that the line marking the elongated trough of low barometer may swing through a considerable angle as the storm moves off to the eastward, with results which are often puzzling when the attempt is made to plot the track of the storm by successive observations of wind and barometer.

F THE NORTHERN HEMISPHERE.

to and around Cyclonic Storm Centers in Oceans
ng which Storms usually Move.

October 31, 1876, in the low lands of the delta of the Ganges, drowned 100,000 people and resulted in the death of as many more through famine and disease. Very strong currents are caused both by the wind force and, apparently, by the advance of the entire storm, which seems to drive the sea bodily before it as well as drag it along behind. Near the coast these effects are most marked, and after a few days in a hurricane, vessels often find themselves 50 or 100 miles out of their reckoning. The widest allowances must therefore be made for current, until the weather clears and good sights can be obtained.

Indications of the Approach of a Hurricane.

Earliest indications.—The distant storm usually causes an abnormal *rise* of the barometer, with cool, dry, fresh winds and cessation or reversal of the ordinary land and sea breezes, with a very transparent atmosphere. A long low swell is often noticed at a great distance, sometimes hundreds of miles, with occasional high hurricane rollers. The direction of the swell, when unaffected by intervening islands and neighboring coasts, indicates the bearing of the center; as do also the light feathery plumes of cirrus cloud that radiate from a point of the horizon marked by a whitish arc.

Unmistakable signs.—As the sky becomes hazy with a thin uniform cirrus veil, halos are noticed by day and night, the barometer begins to fall slowly, the air becomes heavy, hot and moist, with red and violet tints at dawn and sunset; the low but solid and rugged looking cloud-bank of the hurricane appears on the horizon like distant land; squalls break off and diverge from it, and later squalls are noticed passing across the line of bearing of the center of the bank. Fine misty rain forms, seeming to grow out of the atmosphere; a heavy cross sea is felt, and the barometer, while falling rapidly, becomes unsteady.

A vessel situated in front of and near the path of a cyclonic storm will commonly experience a long, heavy swell, a falling barometer with heavy rain, and increasing winds, the direction and changes of which will depend upon her position with reference to the center and the track. A comparison of the three positions of a storm plotted in Plate **120** will show that whereas in Fig. 1, a wind from N.E. or E.N.E. marks a position near

B, in the forward right-hand quadrant (the most dangerous part of the storm), in Fig. 3, the same direction of the wind marks a position near A in the navigable semi-circle and clear of all real danger; while in Fig. 2, it marks a position near C, almost in the track of the storm. This shows the importance of considering the ship's position as to latitude and longitude, in connection with other data; but in attempting to draw conclusions from this it must not be forgotten that the latitude of recurving can be known only in a very general way.

Rules for Manœuvring.

The rules for manœuvring with reference to a storm have for their objects: 1st, to determine the bearing and distance of the center and the track along which it is moving; 2nd, to avoid the center and, if possible, to keep out of or escape from the dangerous semi-circle; 3d, to ride out the storm in safety if unable to escape from it.

It has been shown that the bearing of the center may in some cases be determined, while the storm is at a distance, by observations of the cloud-bank and especially of the point from which the cirrus plumes are seen to radiate; and in some cases, also, by the direction of the long swell which often precedes the storm. But these indications are confined to the early stages of the storm's advance, within the limits of the tropics. Under other circumstances, the only indications of value are the direction and force of the wind and the action of the barometer. The old rule for determining the bearing of the center was to assume it as eight points from the direction of the wind; to the right in the northern hemisphere and to the left in the southern. It is now known that this eight-point rule is true only near the center of the storm, and that near the edge, the center may bear as much as twelve points from the wind.

The following perhaps expresses as definitely as a rule can express it, this relation between the direction of the wind and the bearing of the center of the storm.

Rule.—When the approach of a revolving storm is first clearly recognized, the bearing of the center may be assumed as between 10 and 12 points from the direction of the wind. When the characteristic features of the storm are fully developed, the wind having the force of a gale and the barometer

Plate No. 120.

Fig. 3.

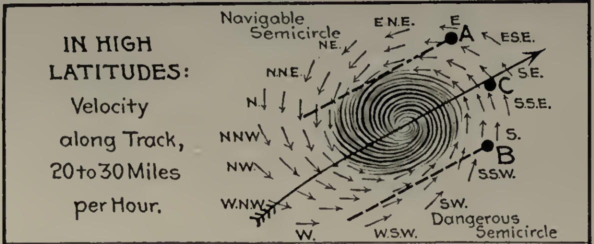


Fig 2.

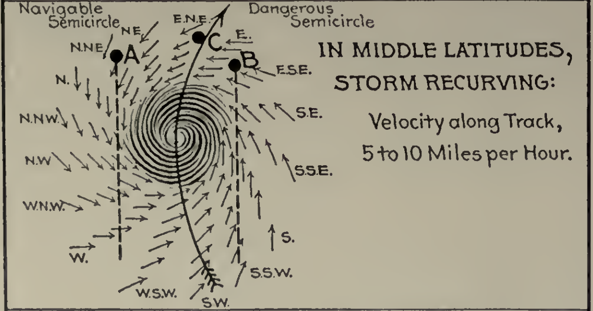
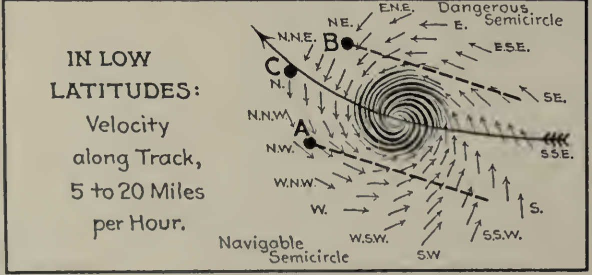


Fig. 1.



Northern Hemisphere.

Fig. 4

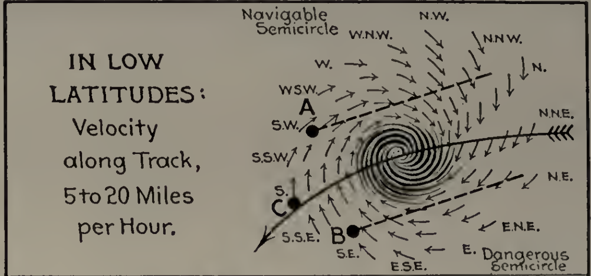


Fig. 5.

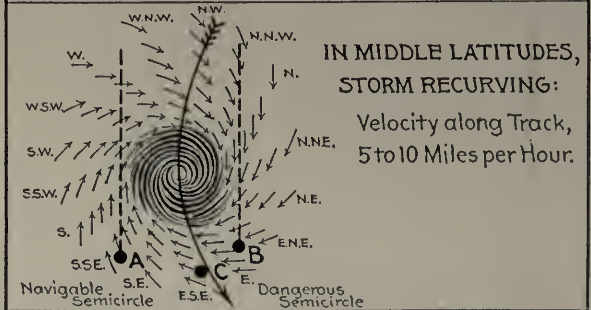
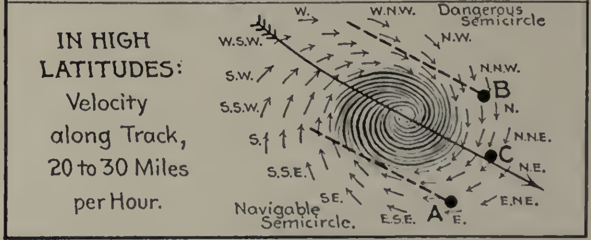


Fig. 6.



Southern Hemisphere.

A HURRICANE RECURVING.

falling steadily, the bearing may be assumed as between eight and ten points. As the storm continues to increase and after the barometer has fallen *as much as half an inch,* the bearing may be taken as about eight points.

It will be understood that neither this rule nor any other one can take the place of an intelligent comprehension and application of the principles which have been explained in the preceding pages.

For data as to the path of the storm, a vessel must heave-to and note the changes in the bearing of the center, and the fall of the barometer.

Plate **119** shows the changes in conditions which would be noted by vessels over which the storm is passing along the different lines there indicated. The hauling of the wind to the right indicates that the vessel is in the right-hand semi-circle; hauling to the left, that she is in the left-hand semi-circle.

This rule holds for both hemispheres; but whereas in the northern hemisphere the dangerous semi-circle is to the right, in the southern hemisphere it is to the left. In either hemisphere, if the wind continues from the same direction with a steadily falling barometer, the chances are that the ship is in the track of the storm. One important exception should, however, be noted. When a hurricane moves along the edge of a trade-wind or monsoon region, the prevailing winds are intensified over a wide area, without appreciable change in direction, giving rise to what are known as "intensified" trades or monsoons. These are illustrated in Fig. I, Plate **122**. In this figure, a vessel at A, hove-to, would have a falling barometer, and no change in the direction of the wind. But if she infers that she is directly in front of the center, and runs before the wind, she plunges directly into the vortex. The only safe course under these conditions is to haul off to the right (in the particular case illustrated in the figure), carrying all the sail that is safe and gaining as much ground to that side as is possible before it becomes necessary to lie-to. *It must be remembered that this applies only to the exceptional case of a hurricane encountered on the border of a trade-wind or monsoon belt.*

It is not a matter of indifference on which tack a ship heaves-to while watching the wind, barometer, and clouds, and waiting for the situation to declare itself. Consider, for example, the ships of Fig. 2, Plate **122**. If the ship B, in the right-hand semi-circle, heaves-to on the starboard tack, the wind and sea will gradually draw aft. If she heaves-to on the port tack, they will draw ahead and she is liable to be taken aback, perhaps in a sudden and violent squall. In the left-hand semi-circle, the conditions are reversed; but here the danger is not in any case as great as in the other semi-circle. The rule is, therefore, in the northern hemisphere, to heave-to *in the beginning* on the starboard tack. If the wind shifts to the right, you are in the dangerous semi-circle and are on the proper tack. If circumstances admit, you may try to work away from the track of the center, close-hauled on the starboard tack. When obliged to lie-to, do so on the same tack.

If, being hove-to on the starboard tack, the wind hauls to the left (ahead), you are in the left-hand or manageable semi-circle, say at A, and heading away from the track of the center. Here you should bring the wind on the starboard quarter and run as long as possible. If obliged to lie-to, do so on the port tack, being careful to make as little headway as possible.

If, the ship being hove-to, the wind remains steady in direction and the barometer continues to fall, it may be assumed, except in the one case which has been discussed above, that the ship is in or near the path of the storm;—say at C. She should run with the wind on the starboard quarter and hold the compass course thus fixed until the barometer begins to rise.

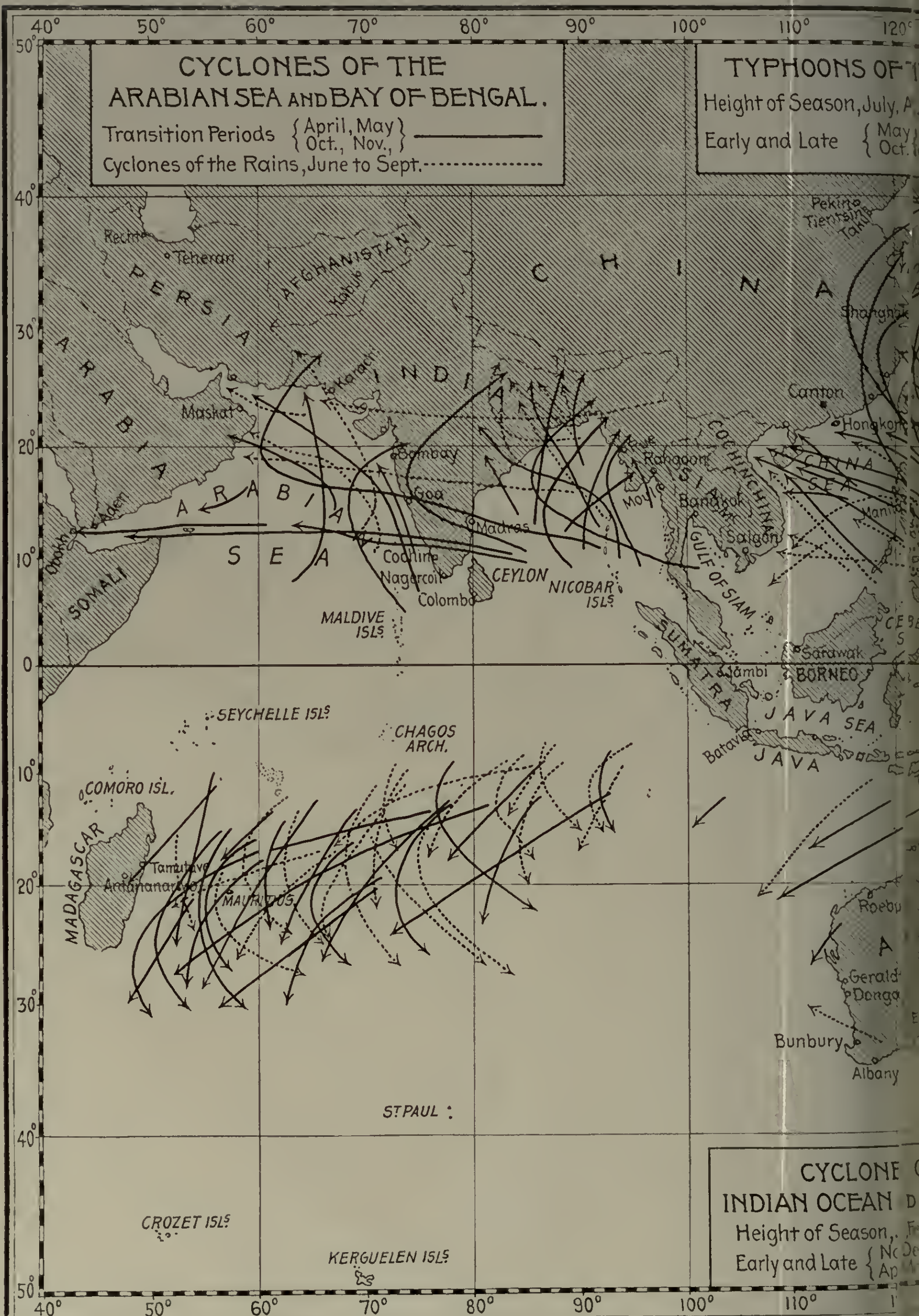
Most of the above rules are reversed for the southern hemisphere. They are summarized for both hemispheres in the following table:

NORTHERN HEMISPHERE.

Heave-to on **Starboard Tack** to note Shift of Wind.

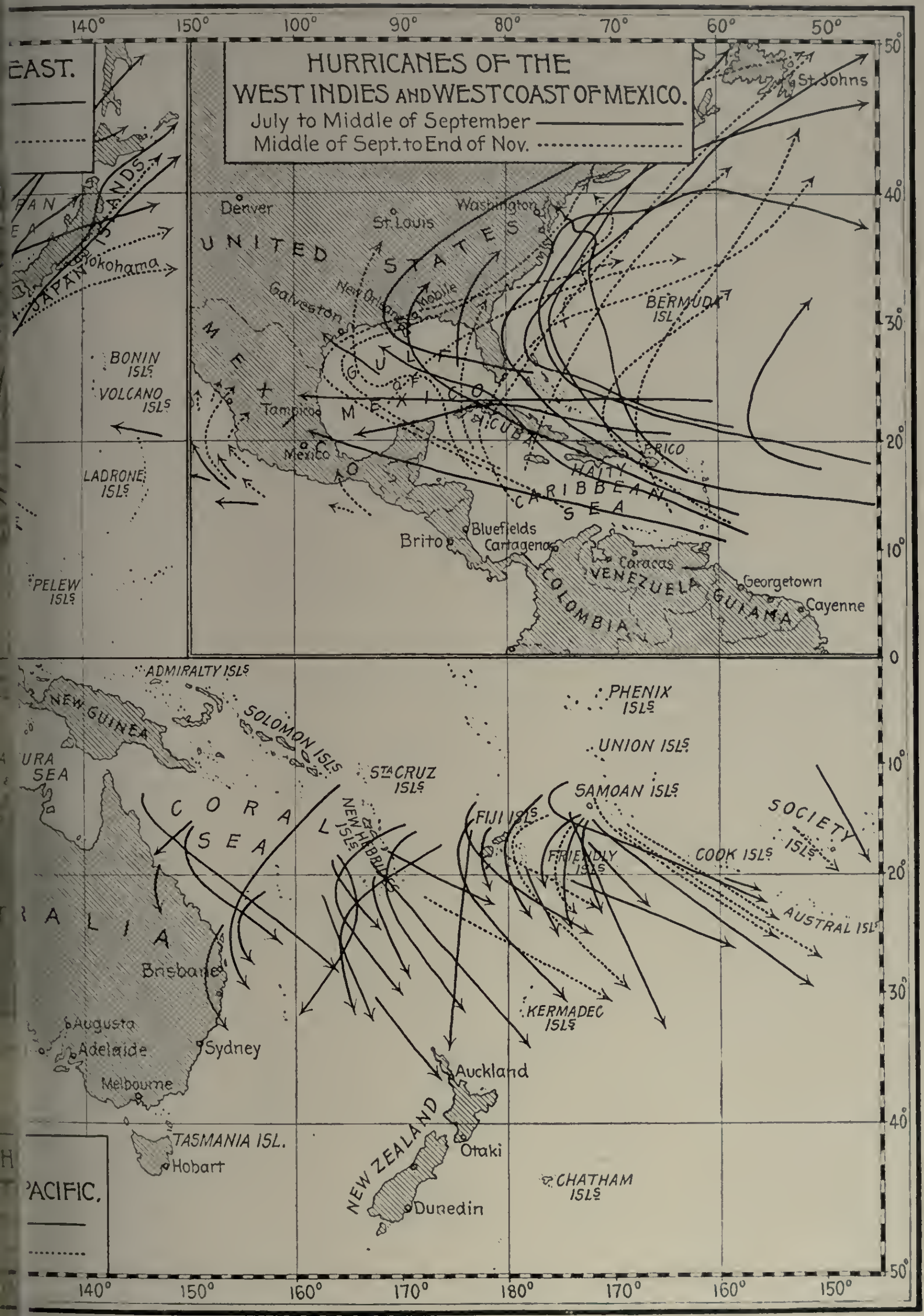
Wind hauls to right	Ship is in right semi-circle DANGEROUS.	Run close hauled on starboard tack. When obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle Manageable.	Run with wind on starboard quarter. If obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on starboard quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

Pla


CYCLONES OF THE ARABIAN SEA AND BAY OF BENGAL.
Transition Periods {April, May / Oct., Nov.,}
Cyclones of the Rains, June to Sept.
TYPHOONS OF
Height of Season, July,
Early and Late { May / Oct.
CYCLONE
INDIAN OCEAN
Height of Season,
Early and Late
40° 50° 60° 70° 80° 90° 100° 110° 120°
50° 40° 30° 20° 10° 0 10° 20° 30° 40° 50°
PERSIA
AFGHANISTAN
CHINA
INDIA
ARABIA
ARABIAN SEA
SOMALI
Recht
Teheran
Kabul
Maskat
Karachi
Bombay
Goa
Madras
Cochin
Nagercoil
Colombo
CEYLON
Aden
Obokh
NICOBAR ISLS
Rangoon
Moulmein
Bangkok
SIAM
COCHINCHINA
Saigon
GULF OF SIAM
Canton
Hongkong
Shanghai
Peking
Tientsin
Taku
CHINA SEA
Manila
SUMATRA
Jambi
Sarawak
BORNEO
JAVA SEA
JAVA
Batavia
MALDIVE ISLS
SEYCHELLE ISLS
CHAGOS ARCH.
COMORO ISL.
MADAGASCAR
Tamatave
Antananarivo
MAURITIUS
ST PAUL
CROZET ISLS
KERGUELEN ISLS
Roebuck
Geraldton
Dongara
Bunbury
Albany

ST

121.


HURRICANES OF THE
WEST INDIES AND WEST COAST OF MEXICO.
July to Middle of September
Middle of Sept. to End of Nov.
EAST.
PACIFIC.
140°
150°
100°
90°
80°
70°
60°
50°
160°
170°
180°
0
10°
20°
30°
40°
JAPAN ISLANDS
Yokohama
BONIN ISLS.
VOLCANO ISLS.
LADRONE ISLS.
PELEW ISLS.
Denver
St. Louis
Washington
UNITED STATES
New Orleans
Mobile
Galveston
MEXICO
GULF OF MEXICO
Tampico
Mexico
CUBA
HAITI
P. RICO
CARIBBEAN SEA
BERMUDA ISL.
St. Johns
Bluefields
Cartagena
Brito
Caracas
VENEZUELA
COLOMBIA
GUIANA
Georgetown
Cayenne
ADMIRALTY ISLS.
NEW GUINEA
SOLOMON ISLS.
URA SEA
STA. CRUZ ISLS.
NEW HEBRIDES ISLS.
CORAL SEA
AUSTRALIA
Brisbane
Augusta
Adelaide
Sydney
Melbourne
TASMANIA ISL.
Hobart
PHENIX ISLS.
UNION ISLS.
SAMOAN ISLS.
FIJI ISLS.
FRIENDLY ISLS.
COOK ISLS.
SOCIETY ISLS.
AUSTRAL ISLS.
KERMADEC ISLS.
Auckland
NEW ZEALAND
Otaki
Dunedin
CHATHAM ISLS.

CKS.

SOUTHERN HEMISPHERE.

Heave-to on **Port Tack** to note Shift of Wind.

Wind hauls to right	Ship is in right semi-circle Manageable.	Run with wind on port quarter. If obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle DANGEROUS.	Run close hauled on port tack. When obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on port-quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

For plotting the position of the ship within the storm from time to time it is convenient to construct a storm-card like Fig. 2, Plate **122**. This should be on tracing cloth and on a good scale. The ship is then drawn on a sheet of paper and the storm-card moved over it in accordance with the motion of the center as determined from the successive observations made as above described. A rough estimate may generally be made of the distance of the center, from the character of the weather, the force of the wind, the fall of the barometer, etc.

It is hardly necessary to say that circumstances may require the modification of the foregoing rules in many directions. One of the most frequent reasons for such modifications is the proximity to land. The influence of this point upon the course to be adopted will be greatly affected by the way in which it is known that the wind will shift. There is less danger in closing with a coast if it is certain that the shifts of wind will be off-shore and not on. So with regard to seeking an anchorage. It may be safe to anchor in an open roadstead if the shifts of wind are bound to be such as to give a lee; it would be hazardous to anchor if the reverse were the case.

Naturally, also, the seaworthiness of the ship, her speed, and many other conditions, are factors in the problem of manœuvring.

The latitude in which the storm is encountered makes a difference because of the difference in intensity; and a vessel may safely hold her course through a storm in the North Atlantic which she would take every means to avoid in the tropics. On the other hand, it is easier to avoid a storm in the tropics than in high latitudes, because of the difference in the area which it covers. The diameter of a hurricane in the tropics rarely exceeds 300 miles, while in high latitudes it may be a thousand miles or more.

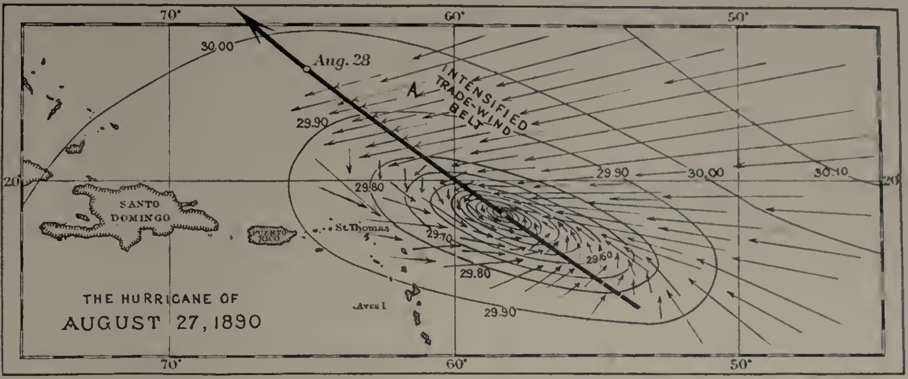
The curvature of the track must be taken into consideration. Vessels have been known to escape from a slow-moving hurricane toward the concave side of the track, only to run into it again after it had recurved.

The preceding directions have especial reference to sailing vessels, but in their general principles they are perfectly applicable to steamers. There is, however, this important difference to be noted; that as a steamer is not dependent for her course upon the direction of the wind, she is much freer to manœuvre and may almost always, unless in the neighborhood of land, keep far enough from the center of the storm to avoid all serious danger. This, however, is true only when the storm is of comparatively limited area and with a center clearly defined; as in positions 1, 2, 3 and 4, of Plate **119**. It is evident that when the storm has spread out over thousands of miles, as in positions 5 and 6, with an elongated trough of low pressure in place of a sharply-defined center, it is hopeless for even a steamer to attempt to avoid it. In such a gale, the directions of the following Chapter (Handling a Steamer in Heavy Weather) become important; and if applied with some reference to the changes in weather which may be anticipated from a study of Plate **119**, they furnish all the directions which should be needed to carry a steamer through any gale in which she has a fair amount of sea-room.

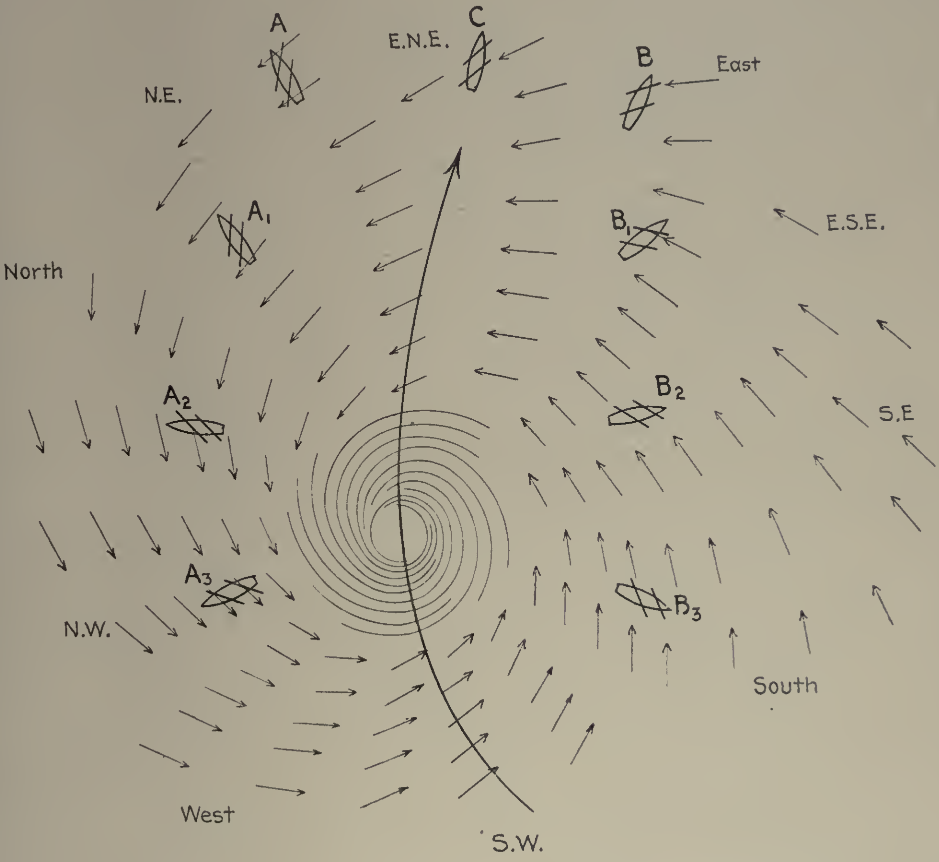
Another point of difference between a steamer and a sailing vessel has to do with the rule for lying-to in the manageable semi-circle. The rule for a sailing ship is to lie-to on the "coming-up" tack in spite of the fact that this brings her head toward the center. For a steamer, the rule in general is to lie-to always with the head away from the center, in order that such headway as is made may be all in the direction of safety.

The Pilot Charts of the North Atlantic and North Pacific

Plate No. 122.



Example of Intensified Trade-Wind Belt.



A Cyclone in the Northern Hemisphere.

SHIFTS OF WIND IN A CYCLONE.

Oceans, issued by the Hydrographic Office of the United States Navy Department, should be familiar to all mariners. These are in substance Monthly Weather Maps of the Ocean and contain a large amount of valuable information not elsewhere to be found, upon a great variety of topics.

CHAPTER XX.

HANDLING STEAMERS IN HEAVY WEATHER.

§ I.

The conventional way of handling a steamer when the weather is too heavy for her to proceed on her course is to bring her up until she has the sea on the bow and to hold her there by the engines and the helm, assisted by such after sail as may be available. In this position, most steamers have a constant tendency to fall off, and can only be held up by giving them way enough for the rudder to exercise considerable steering power. They are thus, to some extent, forced into the sea, and the more it is necessary to force them, the greater the strain to which they are subjected, and the greater the probability of their taking water on board in dangerous quantities. This method of riding out a gale has been handed down from the days of bluff-bowed sailing ships and of steamers with more or less complete sail power. Such ships were held up to wind and sea by their ample after sail, with little or no headway. If they fell off—as from time to time they did—and started to gather way, the hard down helm and after sail would bring them promptly back to meet the sea. Thus they came up and fell off, making some little way through the water, but none of it against the sea; and, in the main, drifting steadily to leeward. For such ships, this was and is the ideal way of riding out a gale. But a modern steamer, whether man-of-war, liner or tramp, carries very little after sail and is commonly long and sharp. The propeller acts as a drag, tending to hold her stern up to the sea, and this tendency is assisted by the excess of draft which such steamers usually have aft. To hold such a steamer bows on to the sea, she must be forced into it—not at great speed, perhaps, but sufficiently to strain the ship severely and to suggest grave doubt as to the wisdom of this method of lying to.

The opinion is gaining ground of late years that a steamer of this type should run slowly before a sea or lie to with the sea astern or on the quarter; and this view is supported both by theoretical considerations and by a convincing amount of practical experience.

If we watch any buoyant object floating in waves which are of some size as compared with the object itself, we shall see that so long as it floats freely, it floats easily, with no indication of strain and with little or no wash on its upper surfaces. If it is forced to lie in some other position than that which it naturally takes, all this is changed; it ceases to ride easily, and the waves break over it more or less. If it is forced through the water, even on the heading which it naturally takes, signs of strain become apparent, and the sea washes over it. If it is forced *against* the sea, the wash will be greater than on any other course, and as the speed in this direction increases, it dives into and cuts through the waves instead of riding over them.

We might anticipate for this that the easiest position for a ship in a heavy sea would be that which she would herself take if left at rest and free from the constraint of engines, helm and sails. For steamers of the type we are now considering (modern steamers of average characteristics), this seems to be generally true. Such a steamer, if left to herself in a seaway will usually fall off until she has the sea abaft the beam, the propeller acting as a drag and holding her stern up. In this position she will roll deeply, but easily, and will drift to leeward, leaving a comparatively smooth wake on the weather beam and quarter, rolling deeply, but in most cases easily, and taking little or no water on board. If oil is used along the weather side and astern, the wake can be converted into an "oil-slick" and all danger of seas breaking on board effectually prevented.

If she rolls dangerously, she may be kept away more, either by setting head sail, by using a drag over the stern, or by turning over the engines just fast enough to give her steerage-way; for it seems to be established also, as the result of experience, that a steamer may safely run with the sea aft or quartering, *provided she runs very slowly*. Clearly this is not "running" in the old sense of that term, according to which a vessel going before the sea was forced to her utmost speed with the idea of keeping ahead of the waves, which were expected to "poop" her if they overtook her. It will be seen from the statements of a large number of shipmasters who have tried the experiment of slowing down or stopping when running before a heavy sea, that this manœuvre, so far from resulting in the disaster which many seamen would expect from it, had an extraordinary effect in easing the ship and keeping her dry.[1]

The explanation of this seems to be that a ship running at high speed through the water draws a wave after her which follows under her counter and rolls along toward the waist on either side, tending continually to curl over and break on board. This wave is reduced to insignificant proportions in running dead slow.

Another point which enters into the behavior of a vessel going before the sea is that as she rolls and pitches she buries first one bow and then the other, increasing the pressure on the bow so buried. If, now, she is being driven through the water, her head will be forced off, first to one side and then to the other, causing her to yaw badly with a continual tendency to broach to; and this cannot be met by the rudder, because, at the very time the bow is buried, the stern is lifted more or less out of the water, and the rudder loses, for the moment, its steering power. As the stern is lifted, there also comes a racing of the propeller which is in itself a serious danger at high speed. Whether these points be sufficient to entirely explain the fact or not, there seems no question that the dangers connected with running, so far from being increased, are greatly reduced if not altogether removed, by slowing or stopping.

It will of course be understood that in this matter, as in all others connected with Seamanship, due regard must be had for the peculiarities of the individual ship; and that the manœuvre which is safest for a majority of ships may be dangerous for certain ones. Thus a ship whose cargo is of a kind that may shift should not be allowed to roll excessively;—nor should a battleship whose heavy guns are carried high above the center of gravity. The same is true to some extent of sailing ships, whose spars may be endangered by rolling too deeply. For such vessels, a course and speed should be maintained which will keep them reasonably steady, even though this may involve some strain upon the hull and some risk of shipping water. But on whatever course the vessel may be kept, this rule may be regarded as of universal application;—that, other things being equal, *the lower the speed at which she is run, the easier she will be.*

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[1] See § IV of this Chapter for the testimony of shipmasters on this subject.

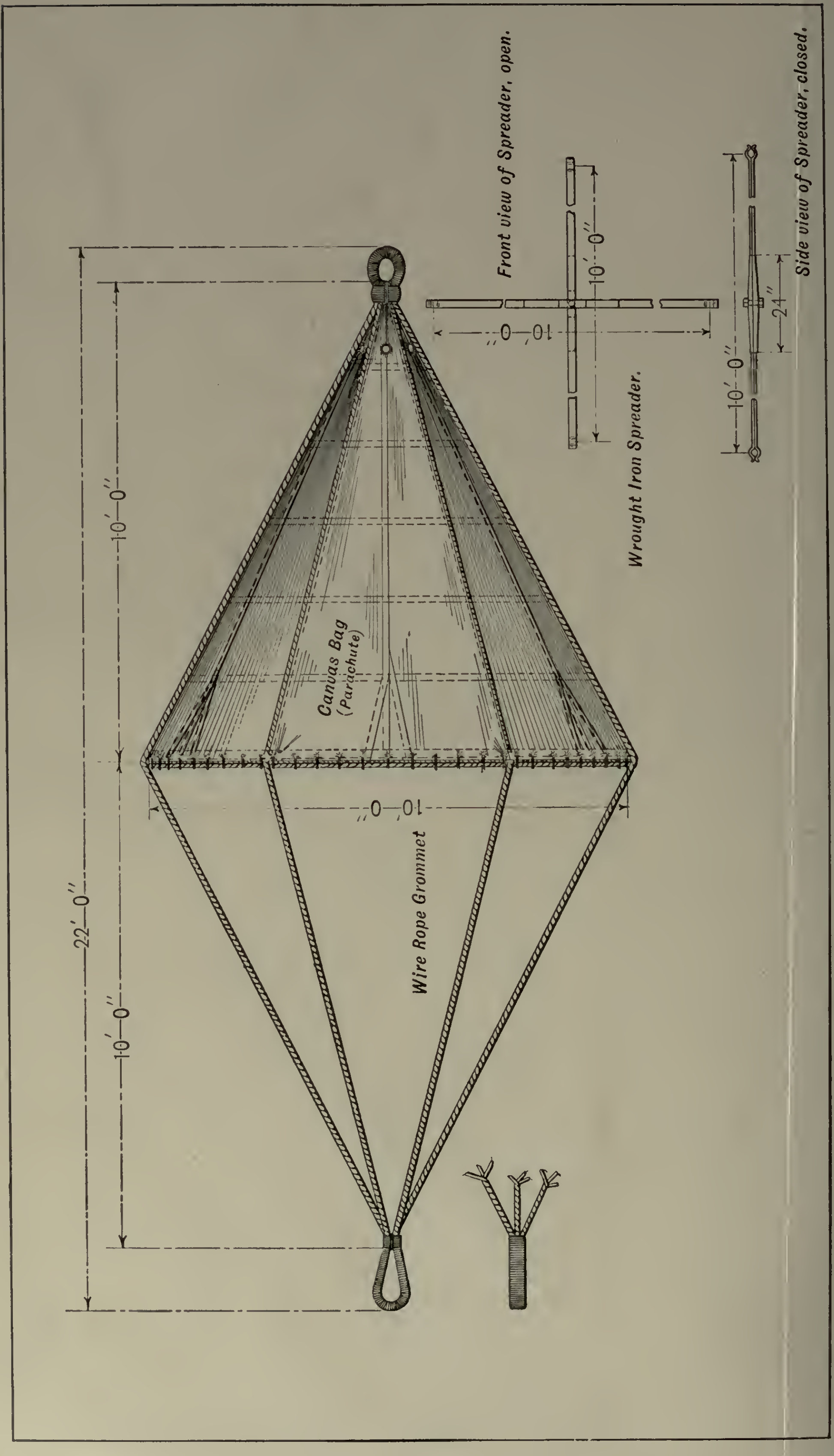
Attention may be called here to an important relation, not always recognized, between a ship and the waves in which she floats. For every ship (in a given condition as to trim, &c.), there is a perfectly definite " rolling period "; a period, that is to say, in which she will make a complete roll, *without regard to whether she is rolling ten degrees or forty.* So, also, in the case of a seaway, there is usually a fairly regular interval of time between wave-crests passing a given point. If the point is a ship in motion, her motion may increase or decrease the interval between the waves so far as she herself is concerned; but this will not change the *regularity* of the interval. If, now, it happens that this interval coincides with that required for the ship to complete a roll, each wave as it passes her will add its rolling impulse to the accumulated effect of those which have preceded it, and the ship will roll more and more deeply until she reaches *the maximum roll of which she is capable.* She will not roll over, if properly designed, because there are forces at work to resist the rolling, and these increase as the depth of roll increases, until the rolling forces and the resisting forces balance. But she will continue to roll to the maximum limit until something is done to break up the synchronism between her period and that of the sea. This can be accomplished, *provided the ship has headway,* by changing the course or the speed or both; thus changing, not the real, but the apparent, period of the waves. By running more nearly into the sea—meeting the waves—the apparent period is shortened; by running more nearly before it, the period is lengthened; but in either case it is *changed* and will no longer agree with the rolling period of the ship. The same affect is produced by a change of speed. If, therefore, it is judged from the violence of the rolling on a given course that the period of the waves is coinciding with that of the ship, the course or speed or both should be changed to break up the synchronism.

If, when a steamer is before the sea or in the trough, it is decided to bring her up to it, bows-on, she should first be slowed until she has barely steerage way, and should then be brought up as gradually as possible. To put the helm down with considerable speed on and bring her up with a rush—slapping the sea in the face, as it were—would result in serious damage, if not in foundering. After getting her up to it, bows-on, the greatest watchfulness is required, first, to avoid falling off into the trough of the sea, as she will try to do the moment she loses way, and second, to avoid driving into the heavy, breaking seas, which will threaten her now and again. There is reason to believe that many of the phenomenal "tidal waves" reported as having suddenly overwhelmed steamers in mid-ocean have been simply the exceptionally heavy waves which build up from time to time in any long continued gale; and that their destructive power was due to the fact that the vessels were driven into them instead of being allowed to drift before them and ride over them unresistingly. An officer should always be kept at the engine room telegraphs, in lying to bows-on, and an engineer standing by below, to obey his signals instantly. So long as she heads up to it, the more slowly she turns over, the better. If a heavy sea is seen bearing down upon her, she should be stopped altogether. If she falls off, it will be necessary to increase the speed a little to bring her up, but she must be slowed again as soon as possible.

The use of a *sea-anchor* is advocated by many writers on Seamanship, and it is commonly assumed that by its use any vessel may be held head to sea and enabled to ride out a gale. No doubt this can be done if the anchor is large enough and strong enough. But considering the importance that is universally attached to this method of riding out a gale, it is surprising how little it seems to have been used and how small is the amount of practical evidence available with regard to it. If used with a modern steamer to keep her head to sea, it acts against the drag of the screw, which, as has been seen, tends to keep her *stern-on* to it; and to overcome this it must be very large and very strongly built; otherwise, its effect will be to keep her in the trough of the sea.

With small ships, and especially with sailing ships, it has been tried often and with good results. Such a ship, riding to leeward of a sea-anchor of fair size with an oil bag hauled out to a block on the hawser well clear of the stem, and drifting slowly astern, will ride out almost any gale with safety and comfort. Indeed, as has been said above, this is the ideal position, in very bad weather, *for any vessel which can be made to take and keep it.* But it is doubtful if a large steamer could be made to

Plate No. 123.



SEA ANCHOR

do this without the use of an anchor too unwieldy to be handled conveniently in a heavy gale. There are certainly few instances recorded of its use with large steamers; and the shipmasters who advocate it for all cases do not claim to have tested it under these conditions.

If, however, the steamer is to be kept *before the sea*, and especially if she is stopped, a sea anchor may be laid out to windward (and astern) with great advantage, since it will in this case act *with* the drag of the screw instead of *against* it, helping to keep her more nearly before the sea.

A convenient type of sea-anchor is shown in Plate **123**. It is merely a large drag, floating but well immersed, and resisting motion through the water by reason of the large area which it presents. It is attached to a line from the ship by a span and has a tripping-line from its apex, for capsizing it, to admit of hauling in.

In cases where a light drag is needed and no sea-anchor is available, a boat may be used, with a hawser made fast to a span from the bow and stern ring bolts, and to a belly band amidships. Or a long spar (or a number of spars lashed together) may be used, also slung by a span. If a topsail or a heavy awning can be added to such an improvised anchor, it will help to break the seas.

There are cases recorded of vessels having been kept head to sea by paying out their chain cables, unbent from the anchors. Where the water is shallow enough for the chains to drag on the bottom, they are especially helpful; in deep water, they have the disadvantage of burying the bow. Where the depth of water admits, a stream anchor or a good sized kedge may be let go with a long scope of cable, either chain or rope, and allowed to drag on the bottom. In comparatively shoal water, a vessel may ride out almost any gale, *at anchor*, provided she has a sufficient scope of cable. During the Civil War in the United States, scores of vessels lay at anchor off the Atlantic coast, and rode out gale after gale, winter and summer, without a single disaster. Under such circumstances, the longer the scope the better; and *one anchor with two cables on end* is preferable to two anchors, each with half the scope of chain.

The engines may be used, but very cautiously, to relieve the strain on the cable if this should be thought too great.

In twin-screw ships, the propellers have not as much drag as with single-screws, and such ships can sometimes be held up to the sea without being driven into it dangerously, by turning over the lee screw very slowly. This is often the best way to lay a twin-screw ship to, although there is nothing in the nature of the case to prevent such a ship from riding easily with the sea astern or quartering.

We may sum up what precedes on the various methods of handling a ship in heavy weather, with the statement that the ship will usually be safest and most comfortable when end-on, or nearly end-on, to the sea, and *drifting before it.*

If, by the use of sails, a drag, or any other means, she can be held bows-on, *while being still allowed to drift,* this is probably the best way to lay her to; but if she cannot be held up without being forced into the sea, it will be because of the natural drag of the stern and propeller, and in this case advantage should be taken of this drag to hold her more or less directly *stern-on,* letting her drift in this way.

Even if the position she takes up in drifting is nearly in the trough of the sea, it will usually be found that she is easier in this position than in any other, but the use of oil, as described below, is especially important in such cases.

If the position which she takes in drifting proves to be one in which she rolls dangerously, then she may run just fast enough to steer, *but no faster,* and so keep the course which is found most comfortable.

§ II. THE USE OF OIL.

The effect of oil in calming a rough sea has been known from the earliest times, but only very recently has advantage been taken of it to any important extent. The very general use that has been made of it in the last few years is due largely to the researches and publications of the Hydrographic Office of the United States Navy Department. Since that Office took the matter up, a great number of shipmasters have experimented with it, and a mass of evidence has been accumulated which leaves no possible doubt with regard to its utility.

Plate No. 124.

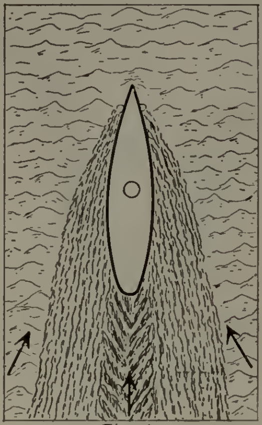


Fig. 1

Running before a Sea.

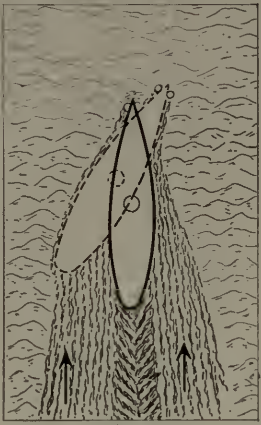


Fig. 2

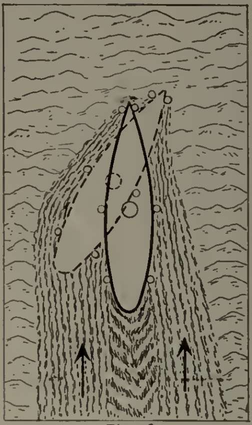


Fig. 3

Running before a Sea and yawing with danger of Broaching-to Distributing oil from bow alone (2) leaves quarter unprotected as ship yaws. Use method of 3.

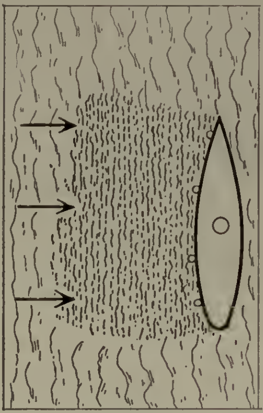


Fig. 4

Lying-to with sea on the beam.

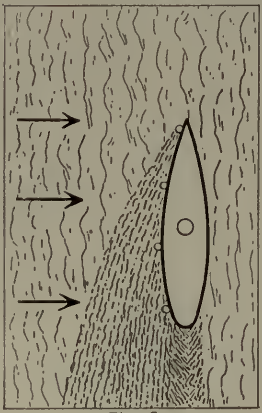


Fig. 5

Running with sea on the beam.

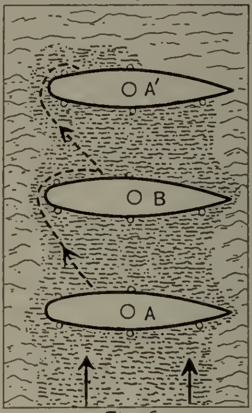


Fig. 6

Communicating by Boat.

Note:-Fig. 6 { *"A" Stops to windward to lower boat and goes to leeward to pick up boat. See Chapters XXI and XXII.*

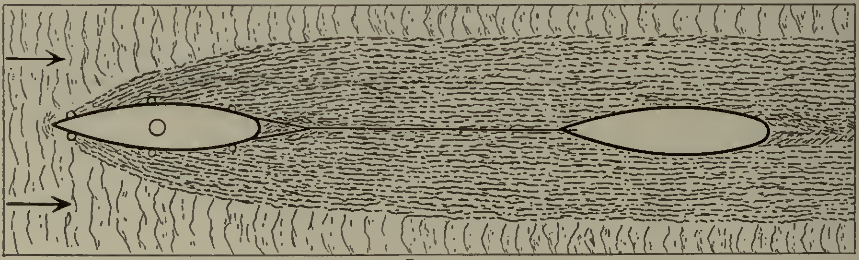


Fig. 7

Towing against a Sea.
if sea is not ahead, both ships use oil as in Fig. 5.

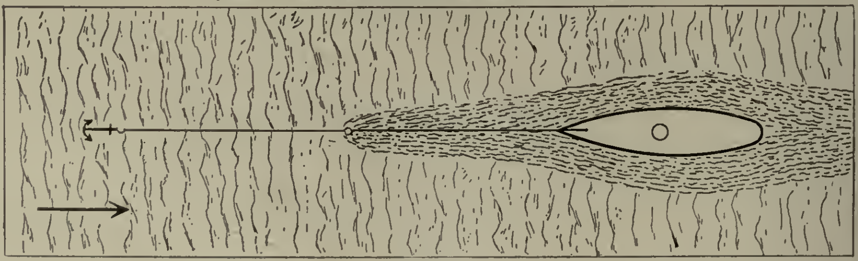


Fig. 8

At Anchor
Haul out bag to block on cable.

THE USE OF OIL

The action of the oil is not only to prevent the breaking of waves, but to a considerable extent also to prevent them from forming, and its effect when used on an angry sea is described by all who have tried it as magical. Even in a surf, while it cannot altogether prevent the waves from breaking as they are driven in upon the shoals, it greatly reduces their violence, and will often enable a boat to land when otherwise it would be out of the question.

Almost any kind of oil will give good results, but some kinds are very much better than others. Animal and vegetable oils are best; for example, sperm, porpoise, linseed, olive and cotton seed; and fairly thick and heavy oils are better than lighter ones. Oil of turpentine is probably the best of all. Mineral oils are much less effective, but a very thick sticky oil or one that tends to thicken or congeal in cold weather, may be improved by thinning with petroleum. Soap-suds has a remarkable effect in preventing the formation of waves, but it does not keep them from breaking when formed.

Any method will answer for using the oil which produces a slow and steady flow. A convenient way is to fill the closet bowls with oakum and oil, or to place a can with a tap slightly opened where it will give a slow drip into the bowls and out through the waste-pipes. A still simpler way and one frequently used is to fill a canvas bag, from one to two feet square, with oakum and oil, and punch a number of holes through the canvas with a sail needle. Such a bag may be hung over the side at any point where it is found to give the best result. If there is danger of its being thrown back on board by the sea, its lanyard may be led through an eye-bolt or a shackle in the side. If for any reason a very rapid flow is wanted, a hose may be led through a scupper or over the rail, and the oil poured into it through a funnel—or, in a sudden emergency, the oil may be *thrown* over the side. The quantity used need not exceed a few gallons—four or five at most—even for a large ship riding out a prolonged gale.

The diagrams of Plate **124** show how the oil may be distributed to advantage under various circumstances.[1] To the cases there illustrated, we may add the following:

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[1] Adapted from an Essay by Captain Karlowa, of the North German Lloyd S. S. Line.

CROSSING A BAR IN HEAVY WEATHER.

Here the oil is needed for a short time only, but in considerable quantities and on both sides. A convenient way of using it is to trail a hose over the bow or through the hawse pipe on each side and to pour the oil freely through this by means of a funnel.

LOWERING AND HOISTING A BOAT IN HEAVY WEATHER.

A boat is always lowered and hoisted to leeward, with the vessel usually either bow or quarter to the sea. A small quantity of oil slowly poured over the side a short distance forward or abaft the boat (depending upon the way she gets the sea) adds greatly to the ease and safety of handling her and gives her a " slick " in which to come alongside or get clear.

It should be noted that the rate at which the oil spreads is slow in comparison with the speed even of a vessel drifting. Thus a vessel lying with engines stopped can make a " slick " to windward but not to leeward—except, perhaps, very close alongside—because she drifts faster than the oil can spread. So, in running, a vessel can leave a slick astern and to some extent on either hand, but can do nothing to calm the waves ahead of her. She can, therefore, avail herself of the benefits of oil if she is running more or less before the sea, but not at all if steaming into it.

§ III. SOME OPINIONS OF SHIPMASTERS UPON LYING-TO IN MODERN STEAMERS.

The author of the present work has collected the views of forty prominent shipmasters upon the subjects of the preceding pages. Of these, thirty-two strongly advocate either stopping the engines entirely, or turning over dead slow and bringing the sea aft or nearly so. Seven prefer to lie to bows on, but think the other method perfectly safe for most steamers. Three have tried the experiment of stopping the engines, but found the rolling so alarming that they were obliged to bring the sea on the bow. It is an interesting fact that these three were captains of large Atlantic liners.

The following are extracts from a few of the letters received:

Captain Otto Nielsen, S. S. Pennland, writes:

"I have laid-to with engines stopped in a terrible sea whilst in command of the S. S. Switzerland, westward bound, facing for several days a heavy westerly gale and enormous high sea. A heavy sea broke on board carrying away after hatches and companions. As the seas had been breaking over more or less and would continue to do so, filling the 'tween-decks with water, and as it was impossible for anybody to be about decks to repair the damage, I was compelled to stop both engines immediately, at the same time starting both oil tanks going fore and aft on the weather side. In less than a minute I could see the oil spreading up to windward and in less than five minutes it had spread at least 300 feet. The ship kept gradually falling off until she was in the trough of the sea. The heavy seas with breakers would come up to the oil and go under it as if it were a blanket and when they reached the ship it was like a long lazy rolling swell, giving the ship a push, but never a bucket of water coming on board.

Of course the ship rolled considerably but in an easy way, and in fifteen minutes after the engines were stopped the decks were perfectly dry fore and aft."

Captain D. Richardson, S. S. Noranmore, writes:

"I find in the North Atlantic great advantage in lying-to with the quarter to the sea. Put the helm hard up and keep the propeller just revolving to break the sea and prevent the rudder being damaged. Use oil from forward, amidships, and on the quarter. This plan was carried out in the S. S. Baltimore in a hurricane on the 2nd and 3rd of February, 1899, off the Grand Banks when so many steamers were disabled and lost. I escaped with little injury."

Captain H. Doxrud, S. S. Rhynland, writes:

"I prefer to stop engines entirely providing I can run oil out liberally.

On the 7th of May, 1898, whilst in command of the American S. S. Pennsylvania, I ran into a hurricane with a tremendous sea. It was impossible without great danger to get along the upper deck, as the seas swept all over her. I was then lying-to, head to sea, and making very bad weather of it. During the height of the storm the engines had to be stopped, the ship fell off with the sea a little abaft the beam and remained so. Oil was used liberally on both sides all the time. The difference in the ship's behavior was simply marvellous. She took little or no water over but was rolling very heavily."

Captain S. W. Watkins, S. S. Montana, writes:

"With my present command I prefer lying-to with the sea right aft, speed reduced and running oil from waste-pipes of W. C.'s, as I find she is much easier that way."

Captain A. R. Mills, S. S. Westernland, writes:

"I prefer to lie to with the engines stopped and the sea quartering. I have tried this several times with different steamers and it worked beautifully. They rolled a good deal, of course, but with a good oil streak to windward they shipped no water."

The following extracts are taken by permission from a valuable paper, "Notes on Handling Ships," by Captain D. Wilson-Barker, published by the Shipmaster's Society, London:

Captain A. H. Brown, S. S. Hunstanton, writes:

"In December, 1886, being in ballast, I was running before a westerly gale and high sea for Memel. Knowing that port could not be entered, and that my vessel could not steam against such weather, I decided on rounding to when about 50 miles off shore. The helm was put down, but the steamer would not answer it; she came to the wind about every half hour, immediately fell off again into the trough of the sea, and drove to leeward at an alarming rate. After about two hours I determined to try her stern on, and did so with most satisfactory results, for although the engines were going slow *astern* we held our own, rolling ceased, and she lay *steadily* quarter to sea. After a while she paid off to nearly right before the wind, and nothing could be better than her behavior; the helm was kept amidships all the time. So satisfactory was the manœuvre that under similar circumstances I have always adopted it since."

Captain J. G. Groombridge, writing of a spar-deck steamer, 3123 tons gross, 400 H. P., says:

"Off Cape Horn, Bar. dropped 29.60 to 28.80 in. during four hours, the wind increasing to a hurricane, it and the sea abeam, the vessel rolling very heavily and shipping much water, fore and aft. I decided to put her before the wind and stop the engines. She then lay with wind and sea on the quarter, and never shipped a drop of water. After this and two other experiences of like character, let wind and sea be ever so violent, I shall never hesitate to act in a similar way."

Captain Jackson of the S. S. Palamed, writes:

"I have had one experience in a typhoon. I found the ship making very bad weather whilst steaming slowly ahead, so after consideration, I stopped the engines and let her take any position she chose. She gradually fell off until we had the wind about four points on the quarter, and there we lay until the blow was done. We did not take any seas on board from the weather side, the cross swell rolled aboard over the lee side, but there was not the least damage done."

Captain Slessar, of the S. S. Pecheli, writes:

"I was caught between Shanghai and Nagasaki in a very heavy gale and high running sea, the ship at the time in ballast trim. As she was continually falling off I at length decided to let her remain so. She laid with the wind a little on the starboard quarter, the helm amidships, if I remember aright; then the engines *were worked slow astern*, with no appreciable difference as regards ship's position. In this way she lay for 30 hours, riding easily."

The following extracts are taken by permission from letters by shipmasters of high professional standing, published by the Nautical Magazine,[1] as part of a discussion of this subject:

One shipmaster writes:

"The question of riding out a gale with engines stopped is a big one and the answer depends upon the type of vessel and her trim; but this I will say, that on no occasion, when in consequence of break-down of machinery or stoppage of engines from other causes, the vessel in which I have been serving has been allowed to take up her own position, has she shipped any heavy water. Many years ago, in mid-winter, when one of the large Atlantic Liners in which I was serving broke down when homeward bound, during an exceptionally heavy gale, and drifted for more than a week, rolling out gale after gale, the only occasion on which she shipped any heavy water was when an attempt was made to bring her head towards the wind by means of a sail, for in those days the Atlantic Liners had masts and yards and could spread a good deal of canvas. Then she relieved the deck of two boats and a house.

Another shipmaster writes:

"Some few years ago, I was running right before a very high N. W. sea, off Belle Isle, in command of a deeply laden tramp. I never remember either before or since seeing so high a sea running in the Bay of Biscay. When abreast of Belle Isle light, distance seven miles, she pooped a tremendous sea, which washed all our deck gear adrift, and started the after bulkheads of both deck bunkers. I at once came to the conclusion something must be done, and that very quickly, or the ship would founder. I then ordered all hands to lower bridge, all deck openings being battened down, intending to bring her head to sea; I therefore eased the engines to slow, to take the way off her prior to bringing her head to sea. Directly the vessel began to lose her way, the effect was simply magical; she shipped no heavy water at all; so I kept on going easy all night, the vessel making splendid weather of it till dawn, when the storm moderated."

Still another writes:

"On Sunday, Nov. 24th, 9 P. M., very heavy gale and very high sea. Ship scudding dead before the sea. The ship, although a very fine seaboat, kept continually filling her fore well (74 feet in length), chock full from rail to rail.

Before putting my oil bags over, I thought, 'here is a grand chance to try how she acts dead slow.' So I eased the engines to dead slow. The moment she lost her strong headway, the effect was magical. The fore well became nearly dry, only a lipper went over occasionally as it rolled along her side, and the ship was as truly comfortable as she could be wished for."

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[1] See an interesting discussion on this subject in the Nautical Magazine for 1895 and 1896.

CHAPTER XXI.

TOWING.

§ I. The TOW-LINE.

Generally speaking, the longer and heavier the tow-line used, the easier the towing will be. A decided dip or "catenary" gives the same advantage here as in the case of a vessel riding at anchor with a good scope of chain;—that is to say, the sagging bight acts as an elastic spring, preventing variations in the tension from being thrown upon the line in sudden jerks; and the sag of the bight depends not only on its length but on its weight.[1] Unfortunately, however, too great weight is a serious inconvenience in handling and running lines. This is the principal objection to chain-cable, which in many ways is an ideal tow-line. Another objection is that if the vessels are obliged to stop, the weight of the chain may prove sufficient to drag them into collision. In the excellent work on Seamanship by Captains Todd and Whall, the use of chain-cable (alone) is recommended for all cases of heavy towing; one of the authors testifying to its availability as the result of his own experience upon several occasions. This is high authority, but the present author has collected the views of more than forty prominent shipmasters, every one of whom says that under no circumstances would he attempt to tow by chain alone, unless compelled to do so.

Wire-rope is very convenient for handling, and makes an excellent tow-line for smooth water, but is much too light to give a satisfactory spring for all-around work under ordinary conditions. All of its advantages may be realized and its disadvantages eliminated, by the use of a *Towing Engine*, which sub-

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[1] Observe that the dip does not in the least reduce the tension of steady towing. What it does is to furnish an elastic link between the ships, by which the forces already described as arising in a seaway are absorbed gradually instead of being thrown upon the line with the suddenness and disastrous effect of "impact."

Plate No. 125.

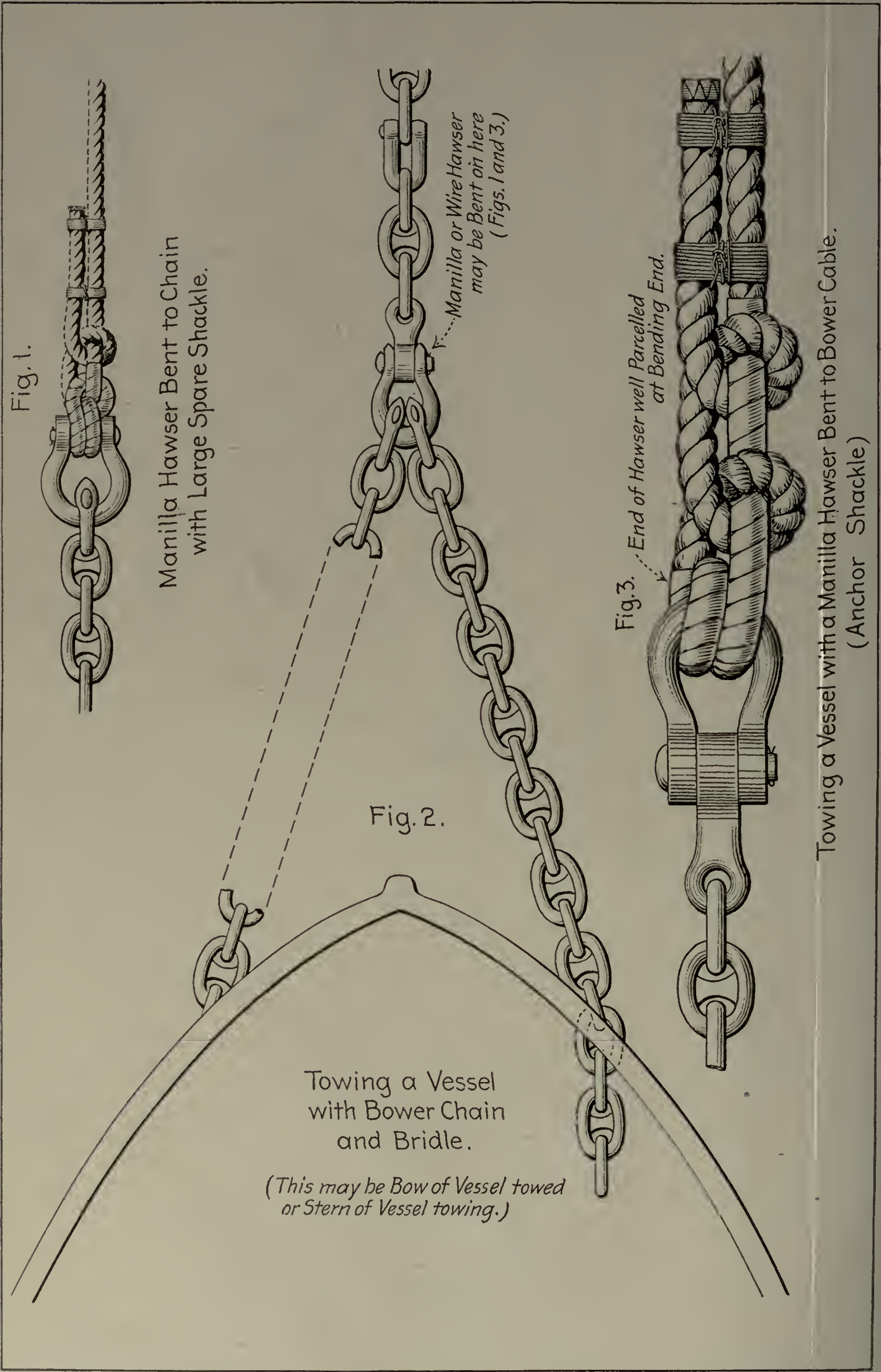

Fig. 1. Manilla Hawser Bent to Chain with Large Spare Shackle.

Fig. 2. Towing a Vessel with Bower Chain and Bridle.

(This may be Bow of Vessel towed or Stern of Vessel towing.)

Fig. 3. Towing a Vessel with a Manilla Hawser Bent to Bower Cable. (Anchor Shackle)

Manilla or Wire Hawser may be Bent on here (Figs. 1 and 3.)
End of Hawser well Parcelled at Bending End.

SECURING TOW-LINES.

stitutes the elasticity of steam pressure for that due to a long and heavy line. This will be referred to at greater length hereafter.

Both chain and wire have a serious disadvantage in that they are not buoyant, as are lines made from vegetable fibre.

Manila and **Coir,** while heavy enough to give a good dip if used in sufficient length, are not too heavy for convenient handling, and their buoyancy is a great advantage, particularly where lines are to be run by boats or hauled across over considerable distances. Manila, although much less buoyant than coir, is more commonly used and is probably upon the whole the most satisfactory line that can be used for moderate towing; but although heavier than wire of corresponding strength, it is still much too light for towing in a seaway. Its weight is increased in some cases by hanging a good sized kedge to the bight between the two ships;—a device which is evidently available with wire, as well as with manila. A more common plan is to use a combination of chain-cable with a manila or wire hawser, the hawser being made fast to the towing ship and the chain-cable paid out by the tow. The length that is needed will vary with circumstances, but it is always better to have too much than too little. For towing a large ship against a sea, the full length of the best hawser available, with 45 or 60 fathoms on the bower cable, will be none too much.

A point of some importance in towing in a seaway is to keep the ships "in step" as nearly as may be; that is, to use such a length of line that they shall meet the waves and ride over them together. If the length of the line is such that one vessel is in the trough of the sea as the other is on the crest, the line will for a moment slacken, then tauten out with a sudden jerk; whereas if they meet the waves at the same time the tension on the line will remain comparatively steady. The wave-lengths of a sea are usually approximately uniform at any given time, and it should not be difficult to arrange the line as above described by heaving in or veering away the cable on the tow. In towing for a long time and covering a great distance, extreme variations may of course be found in wave-lengths, and the inconvenience of changing the length of the line from time to time may more than offset the advantage to be gained; but it is worth while to recognize this point and to be ready to take advantage of it when circumstances permit.

Securing the Line.—The line is usually secured to the stern of the towing ship by a span from quarter to quarter, which may be of chain, wire, or manila;—chain being perhaps the best. Whatever method is adopted, it is very important that arrangements should be made for letting go quickly in case of an emergency. Where chain is used for the span, two lengths of bower cable are gotten aft, one on each side, and passed through the quarter-chocks. The outer ends are then brought in over the rail and connected together by an anchor shackle, to which the end of the towing hawser is also made fast; care being taken to use plenty of parcelling in the bend (Plate **125**). A bull-rope is made fast to the shackle, for lowering the span over the stern after the lines have been secured and for heaving the span up to the rail if the line parts or if it is desired to let go.

The details of securing the lines inboard must of course depend upon circumstances, but it is important to distribute the strain over as many sets of bitts as possible, and, as already remarked, to arrange for letting go in a hurry. The plan shown in Plate **126** covers these and other points. Here the inboard part of each cable is taken around three successive sets of bitts and a good manila hawser is bent to the end and secured to the foremast. A deck house might be used in place of the foremast with the advantage of distributing the strain over a number of deck beams. If it becomes necessary to slip in a hurry, the manila lines are eased away as far as necessary, then cut. Or they may of course be cut at once, care being taken that no one is in the way of the cable as it unreeves. The manila gives a certain elasticity to the lines, and this may be increased, if it is thought desirable, by a manila spring[1] or a heavy purchase from the cable to the mainmast or some other convenient point.

Another way of fitting a span is to bring the tow-line in through the quarter-pipe on one side and bend a hawser to it from the other quarter-pipe at such a point outside that the two parts shall form a span of convenient length. The lines may be made fast around the bitts and to the mast or a deck house in practically the same way as the chains in the method previously described. This plan has the advantage that by letting go the second line we get rid of the span at once and have to deal only with the tow-line itself.

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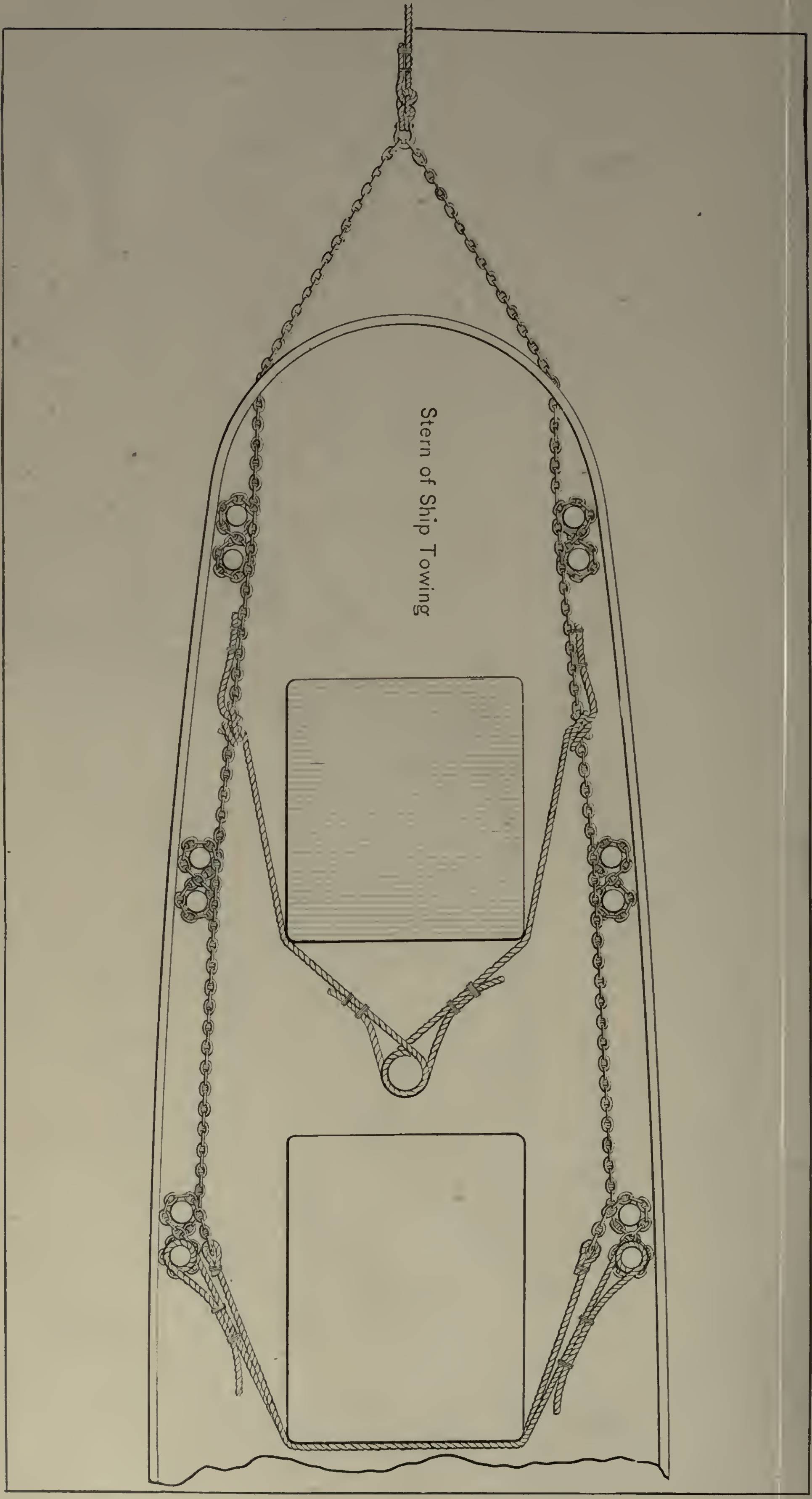
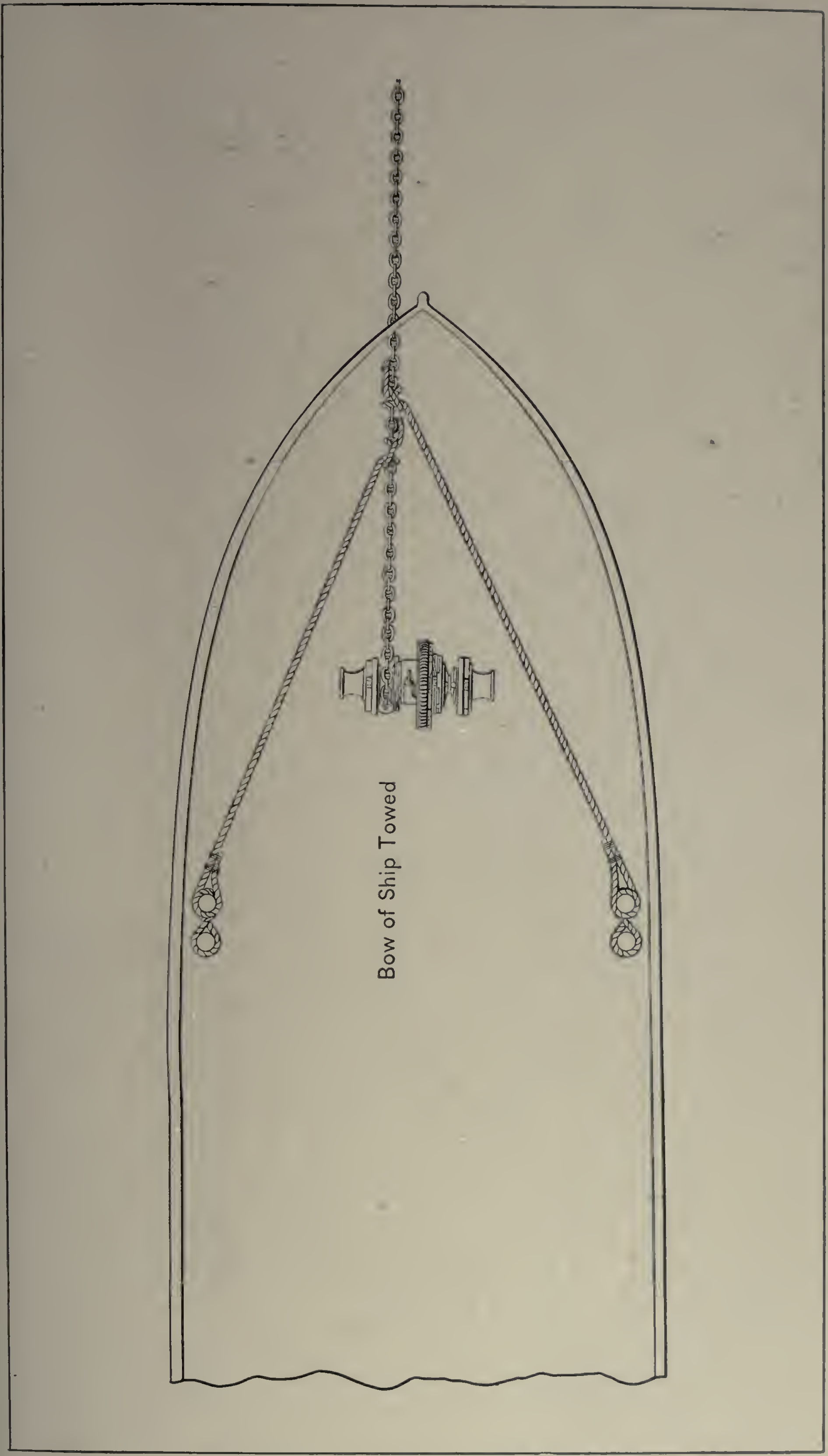
[1] Note the distinction between the term "spring" as used here and in the chapter "Handling Steamers around a Dock."

Plate No. 126.



SECURING LINES IN TOWING.

Plate No. 127.



SECURING LINES IN TOWING.

If the tow-line is of wire and fitted with an eye in the end, a span may be formed of several parts of a wire hawser rove through the eye and brought in through the quarter pipes. The parts should be taken around the bitts in such a way that they can render freely and so equalize the strain.

A span is sometimes used from the bows of the tow, the line being bent to this as in Plate **125** (for example). This is desirable and even necessary *in cases where the tow is unable to steer*, but it is an altogether unnecessary complication and embarrassment in other cases. A vessel which can steer will follow in the wake of her leader with a very small amount of helm even when the tow-line leads from a pipe some distance to one side of the stem; and she is free to shorten in or to veer, to let go or to run in the line, at any moment.

Frequently two tow-lines are used, one from each quarter of the towing ship to the corresponding bow of the tow. This is an excellent plan, but it must not be forgotten that while the work of towing will usually be divided between the two lines, there will be times, in changing course and in sheering about, when all or nearly all of the work will be thrown upon one. Where two lines are used in this way, a length of chain is often bent to the end of each (at the towing ship), to avoid chafe in the pipe and at the bitts, and to add by its weight to the dip and elasticity of the lines. Two lines used in this way may be made fast as has been described above for the two parts of the bridle.

Where the total length of line available is limited, it is worth while to consider, in the light of what has been said about the advantage of a long line and a dipping bight, whether two hawsers will not be better employed if bent together and used as a single line of double length than if used separately as above.

On board the tow, the hawser is bent to the bower cable (see Plate **125**) and the cable veered away to the length which has been decided upon. It is usually left on the windlass, but the actual strain of towing is taken by one or more springs of manila or coir bent on forward of the windlass and made fast as far aft as practicable. This not only relieves the windlass, but adds still another element of elasticity to the line (Plate **127**).

The windlass brake should be set up, so that if the springs part the chain will not be adrift altogether.

It is well to have a shackle between the windlass and the point to which the springs are bent, with tools at hand for unshackling if necessary. This, however, should be done by the tow only in an extreme emergency, as the line, weighed with a considerable length of chain, would sink immediately and hang as dead weight down from the stern of the towing vessel, endangering the screw and effectually crippling her until she could cut it adrift. Hauling it in under such circumstances would be out of the question.

It is customary to have a large thimble spliced into each end of a wire hawser which may be wanted for towing, and to use a shackle when making fast to another line or cable. To bend the line back sharply upon itself, as would be necessary in any other method of bending on, would weaken it seriously. So in leading it through a pipe or making fast to a bitt, a sharp nip should be avoided.

§ II. TOWING IN SMOOTH WATER.

In smooth water, the tension on the tow-line will be constant, after the inertia is overcome, so long as the speed does not vary. The following table gives the approximate values of this tension for ships of various sizes when towed at speeds from 2 to 8 knots.

Approximate Tow-rope Resistances for Smooth Water.

Displacement of Vessels towed.	Speed.			
Tons.	2 knots.	4 knots.	6 knots.	8 knots.
1000	310 lbs.	1250 lbs.	2800 lbs.	5000 lbs.
2000	540 "	2050 "	4800 "	8600 "
3000	675 "	2700 "	6050 "	10800 "
4000	830 "	3300 "	7500 "	13500 "
5000	960 "	3800 "	8600 "	15000 "
6000	1075 "	4250 "	9500 "	17000 "

Note that if the vessel towed is long and fine, the resistances will be less than those above, while if she is short and bluff, they will be greater.

A Table of the strength of ropes is given in Chapter II. Taken in connection with the one given above, it furnishes a rough guide to the size of line required for any given case of towing *in smooth water*. It indicates, also, the speed at which it will be safe to tow in smooth water with a given line, and this is probably its most useful application.

It must be understood that the tensions of the above Table suppose the vessels *to be actually moving with the speeds given.* When the tow is at rest, the problem of overcoming her inertia and getting her up to the uniform speed desired, is very different from that of towing her after she acquires this speed; and as something of a jerk is inevitable, it is essential to use a line considerably longer and stronger than would be necessary for steady towing.

The tauter the line can be made before the towing vessel starts her engines ahead, the better it will be. She will of course start as slowly as possible, and, having overcome the inertia of the tow, work up, a fraction of a turn at a time, to the speed required. In gathering way at the very beginning it is well to give a few turns ahead, then stop the engine, then give a few more turns and stop, and so on.

In all cases of towing ahead, the farther forward on the towing ship the line can be made fast, the easier will be the steering, as the stern of the towing vessel is free to swing off to either side in obedience to the helm. In a large vessel it is usually necessary to make fast near the stern, or, what comes to the same thing, to lead the line in through a stern or quarter chock or use a span from both quarters. But a *tug* designed for towing should have the bitts well forward and be fitted with some arrangement at the stern for letting the line swing over to the quarter if it becomes necessary to turn sharply. This need not prevent the line from being held amidships so long as the towing is on a straight course.

§ III. TAKING A DISABLED VESSEL IN TOW AT SEA.

In good weather, this manœuvre presents no especial difficulty and calls for no extended discussion. The lines are run by boats and secured as already described. The towing vessel starts ahead slowly on the course upon which the disabled vessel happens to be heading, using every precaution to prevent a jerk on the line, and waiting, before changing the course, until both ships have gathered way and are moving steadily with a good tension on the line.

In very bad weather, on the other hand, towing should not be attempted unless exceptional circumstances make it necessary; as the running of lines in a heavy sea is attended by difficulty and danger; and even if they are run successfully, the chances are much against their holding.

It will be considered in the discussion which follows, that the weather is rough enough to call for the use of all reasonable precautions, but not rough enough to make towing impracticable. It may be assumed that the disabled vessel will be lying with wind and sea a little abaft the beam;—this being the position which a steamer usually takes up when lying in a seaway with engines stopped. The other vessel places herself on a parallel heading, either to windward or to leeward. In considering which of these positions is to be preferred, we must remember that a considerable time will be required to run the lines; and that, during this time, both vessels will be drifting to leeward at a rate which may make their drift a very important factor in the problem of manœuvring. A vessel which is light will drift faster than one which is loaded, the drift of a vessel in ballast-trim amounting often to several knots an hour. If the lighter vessel is to leeward, she will drift away from the other, making it very difficult to run the lines. It may be said, therefore, that as a general rule, if there is any important difference in the rate of drift of the two vessels, the lighter one should be to windward when the work of running the lines is begun.

If there is any doubt as to which vessel is drifting the faster, this can be determined in a few moments by placing the one which is able to manœuvre, in line with the other and on the same heading.

The towing vessel, then, places herself to windward if she is drifting faster than the other vessel, and to leeward if she is drifting more slowly, and on the same heading as the disabled vessel; taking care of course, not to run any risk of drifting into collision. All danger of this can be avoided by going a little on the bow; but this involves a partial loss of the lee that should exist between the two ships if one is to leeward of the other, and of the "oil-slick" which the vessel to leeward can create to windward.[1]

Some seamen recommend placing the towing vessel to windward and heading up to the sea or nearly so. But to hold her up in this position it would be necessary to keep the engines turning, which would result in drawing away from the other vessel and add greatly to the difficulty of the situation.

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[1] The oil from a vessel drifting in a seaway will not spread to leeward as fast as the vessel will drift. It is therefore impossible to make an oil-slick on the lee side, except, perhaps, very close aboard.

Where the difference in the rate of drifting is considerable, the time available for running the lines after the work is once begun will be short at best and every precaution should be taken to prevent delay; a clear understanding being established between the ships and all preparations made, before the towing ship takes her position as above. In communicating between two ships, megaphones are of the greatest value. Under any except the most unfavorable conditions, they should make it possible to perfect a thorough understanding of what is to be done and how. They also to a great extent take the place of signals between the two ships after the towing begins, although a code should by all means be adopted and will be useful under many conditions. It is an excellent plan, when feasible, to send an officer on board the tow to remain there permanently; acquainting him first with the plan to be carried out and providing him with a list of whistle- and sight-signals for handling the lines and the ships. If no boats are to be used, a paper should be floated across to the tow, giving full instructions and a list of the signals. This may be sealed up in a bottle and attached to the rope or the float. Whistle signals are preferable to flags, because they can be used at night or in a fog.

The following is suggested:

Code of Sound Signals for Towing.

A short blast must not exceed 2 seconds in length.

A long blast must not be less than 6 seconds in length.

I am putting my helm to port	1 short blast.
I am putting my helm to starboard	2 short blasts.
Go ahead	2 long.
Stop	1 long, 2 short.
All fast	2 long, 1 short.
Haul away	2 short, 1 long.
Let go	3 long.
Pay out more line	1 short, 2 long.
Avast hauling	3 short.
I am letting go (emergency)	5 short, 5 short, 5 short.

The first line to be run will be a light one, by means of which the heavier ones can be hauled across. A 3-inch manila is a convenient size to begin with. If new, so much the better, as it will float freely. If a boat is to be used it should be lowered with the crew and the greater part of the line in it, and gotten clear as quickly as possible, the line being paid out as the boat pulls away for the other ship.

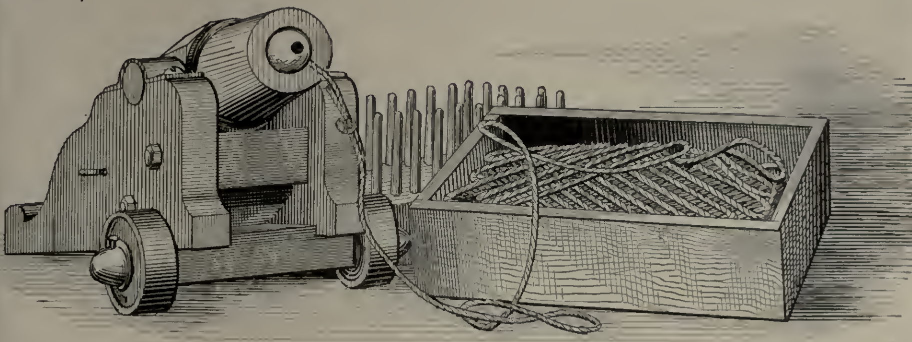
If it is not thought best to use a boat, the line may be floated alongside the disabled ship without much difficulty. The best way to do this will depend upon circumstances, but a common way is to float a good length of the line by life-belts, casks, or any other convenient means, and to steam slowly around the disabled vessel, dragging this astern and causing it to foul her. If proposing to take up a position on her weather bow it is a good plan to steam along to leeward, fairly close aboard, cross the stern, and come around parallel to her heading. This will cause the line to foul her stern, which entails a little trouble in shifting it forward, but it leaves the towing ship in position without further manœuvring. Similarly, if proposing to take a position on the lee bow, pass along to windward, cross the stern and come around to leeward. The line should be picked up without difficulty.

Many vessels are provided with rocket guns throwing a line-carrying projectile similar to that used in the life-saving service. This is very useful and may save a great deal of trouble and delay. Such a gun is shown in Plate **128**.

In Todd and Whall's Seamanship, the use of an ordinary 1-lb. ship's rocket is said to afford an excellent method of establishing communication. Such a rocket, it is stated, will carry a small fishing-line over 200 feet athwart the wind. If proposing to use this method, it will be better to go to windward and as close as is prudent. The fishing line is faked down on deck, clear for running, with one end fast on board and the other bent to the rocket stick a few inches from the end. The rocket is given a good elevation (about 45°), and fired. If connection is successfully made, a somewhat heavier line is bent on and hauled across and so on until a sufficiently heavy one has been run to haul over the tow-line.

There may be special circumstances which will make it desirable for the disabled vessel to run the lines, but under ordinary circumstances it is more convenient for the towing vessel

Fig. 1



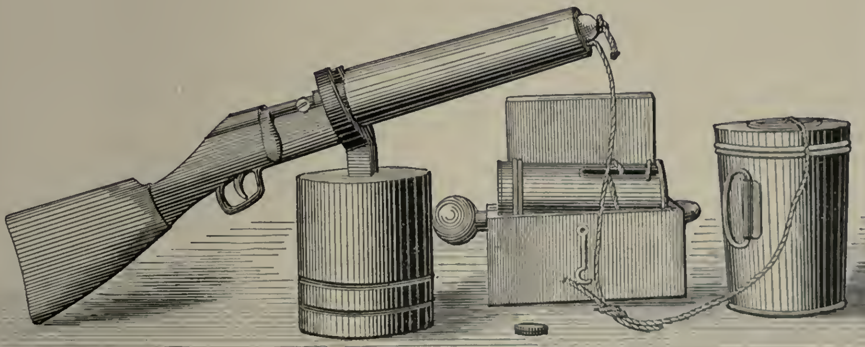


Fig. 2

LINE-THROWING GUNS.
(B. Cordes, Bremerhaven.)

to run them. Having gotten the first light-line across, by whatever method, the heavier lines are run and made fast to the bower cable of the vessel to be towed (see Plate **125**). A good length of cable is paid out;—60 or 75 fathoms is none too much for heavy work;—and the line made secure on both ships as has been described in § I, chafing-gear being used liberally wherever it can be needed. In the meantime, full instructions about starting are given to the Chief Engineer, and when all is ready the engines are started ahead as slow as possible, and stopped the moment the line begins to tauten out; then a few more turns are made, and so on until the inertia of the tow is overcome and both ships are moving slowly with a steady tension on the line. The revolutions are then increased little by little and the course changed gradually, as may be necessary. When, finally, the tow is straightened out and moving steadily, the speed is worked up to that at which it is thought wise to continue.

In all changes of course, the tow puts her helm at first to the side opposite that of the leader, and so steers around into the leader's wake.

If the sea is such as makes it dangerous to tow to windward, it is worth while to consider whether a port cannot be made on a course which will present fewer difficulties, even if the distance is much greater.

After settling down to a steady rate of towing, the lines should be examined, springs hauled taut afresh, the strain divided as evenly as possible, chafing gear renewed wherever necessary, etc. Hands should be stationed night and day to watch the lines on both ships, with axes and unshackling tools ready for slipping hurriedly if necessary. It is well to have a light "messenger" line between the ships, for hauling messages across and for use in running a new-line in case of necessity. This line should be left slack and should have ample length to allow for the fact that if the tow-line parts the leading ship will forge ahead considerably before she can be stopped. If such a line is not used, messages may be floated across by paying out and hauling in a light line like an old-fashioned log-line.

The towing vessel should use oil freely as in Plate **124**.

In casting off, the towing vessel should preferably be the one to let go; for if the other one does so, the towing vessel will have the line hanging over her stern, where it endangers the screw and cannot be handled without great difficulty. In a sudden emergency, both vessels cast off together.

§ IV. TOWING ENGINES. TOWING ALONGSIDE.

Towing Engines.[1]—In the United States, vessels designed especially for towing are in most cases fitted with towing-engines, which carry the line on a reel and pay out and haul in automatically as may be necessary to keep the tension constant; the resistance of the tow being borne entirely by the steam pressure in the cylinders. If the tension on the hawser rises momentarily above this steam pressure, the drum revolves and pays out line. This action opens the regulating valve and increases the steam pressure in the cylinders until this pressure balances the tension on the line. If, later, the tension decreases, the steam pressure will be in excess and the drum will revolve and reel in the line, but at the same time the regulating valve will close in part, and the pressure will fall until it meets and balances the tension. In this way, the line is payed out or reeled in only just enough to meet the condition of things prevailing at any given moment, and the average length of line remains practically constant.

There can be no question of the enormous advantage in towing resulting from the use of these engines. A point of great, though perhaps secondary, importance, is that if the towing vessel stops, or if for any other reason the tow ranges up and slacks the line, the engine takes in the slack at once and keeps it clear of the screw. If it is found desirable at any time to shorten in the line, reducing the distance between the vessels, it can be done without difficulty. This may be important in passing around bends in a channel, or for taking in the line preparatory to casting off.

It is not the least of the advantages of the towing engine that it makes the use of wire-rope perfectly safe in all weathers.

Towing Alongside.—When towing in port or in confined waters, the tug should be made fast alongside if possible, as this gives greater ease and certainty in handling. When used in this way, the tug is usually placed on the quarter, where its rudder acts with that of the tow, for steering. As the power is applied at a distance from the midship line, there is here a considerable turning moment, which will throw the ship's head to one side or the other, according as the tug goes ahead or backs; the effect being exactly as if the ship had twin screws and was using only one of them. In going straight ahead, the turning effect is neutralized by a small amount of helm.

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[1] American Ship Windlass Co., Providence, R. I.

The tug must be made fast with a line from aft for going ahead and one from forward for backing. Both of these lines are usually made fast at the bow of the tug, her stern being held from swinging out by a breast-fast leading to the tow (Plate 109).

If the tug has a right-handed screw, she will handle better if made fast on the port side; since, in backing, the tendency of her screw is to throw her stern out to port, while the tendency due to her position on the port side of the tow is to throw the stern of the tow the other way. Thus she will make a straighter sternboard than if made fast to the starboard side, where both these elements would tend to throw the stern off to port.

CHAPTER XXII.

RESCUING THE CREW OF A WRECK.

The situation here is somewhat like that where one ship is to take another in tow, but with several important points of difference. No matter how bad the weather may be, the work of rescue, if it is to be attempted at all, must usually be undertaken at once; and in practically all cases, by means of a boat. On the other hand, the rescuing ship is much freer to manœuvre than when she is hampered by lines as in making preparations for towing.

The natural way of proceeding under ordinary circumstances is to go to windward of the wreck and lower a boat, then go to leeward and stand by to pick it up. If oil is used along the weather side of the wreck, the boat will have an oil-slick, in addition to the lee afforded by her own vessel; and if the rescuing vessel uses oil after getting into position to leeward, the slick may be continued so that the boat shall have the benefit of it as she returns, loaded, before the sea. If for any reason the wreck cannot use oil, the rescuing vessel can steam around her, running oil freely and so creating a slick into which the wreck will presently drift.

If the weather is very rough, extreme precautions will be called for in lowering the boat and getting her clear. The ship should be held up with the sea on the bow, giving a lee for the boat and reducing the rolling as much as possible. The crew is lowered in the boat, with life-belts on. A painter is used from well forward, brought in on the inboard bow of the boat and tended with a turn around a thwart, and the steering oar is shipped in its crutch, ready to assist in sheering off clear of the side as soon as the boat is in the water. Frapping lines may be used around the falls to steady the boat, and sails or mattresses hung over the side as fenders, to prevent the boat from being stove if she swings in heavily. Two or three extra life-belts should be taken along, with two heaving lines bent to each. These are for hauling back and forth between the boat and the wreck. Oil-bags should be hung from the bows of the boat.

As the boat strikes the water the falls are unhooked (after-fall first) and the painter passed quickly aft and hauled in, shooting the boat ahead and sheering her off at the same time. The vessel should be nearly dead in the water when the boat is lowered, but a little headway may be needed to keep her up to the sea.

Assuming that the boat gets off and makes the trip to the wreck in safety, the officer in charge must decide how he will establish communication and take off the passengers and crew. It is out of the question to go alongside to windward; and if he goes alongside to leeward, not only is there a risk of being stove by the wreckage which is likely to be found floating under the quarter, but there is the much more serious danger of being unable to get clear of the side again. As has been explained in the Chapter on Towing, a vessel lying in a seaway with engines stopped drifts to leeward at a rate which is always considerable and may amount to several knots an hour. A boat alongside such a ship, to leeward, is in exactly the same position as if she were alongside a dock against the face of which a strong current is setting. Every one knows how helpless a boat is under these conditions so far as getting clear is concerned. As a rule, then, the boat must never be brought actually alongside the wreck. She may either lie off to windward, being held up head to sea by the oars, or to leeward, holding on with a line from her bow to the wreck, with a few oars at work backing, to keep her at a safe distance. It may be well to let the men at the oars face forward to make sure of being able to keep off. The people on board the wreck put on the life-belts, jump overboard one at a time, and are hauled into the boat.

So serious is the question of avoiding actual contact with the wreck, that many officers consider it best for the rescuing ship to go to windward and drop the boat down with a line, putting only two or three men in the boat. This is the plan recommended by Captains Todd and Whall in their Seamanship, and it is endorsed by a number of experienced officers who have favored the present author with their views; but a large majority of the officers who have written on this subject take the ground that a boat is always safer and more manageable with a full crew, and that to drop her down with a line from the ship simply hampers the manœuvring of both the ship and the boat without any sufficient compensating advantages. If proposing to drop the boat down with a line, it is important to make sure of having this of sufficient length. One end should be passed through the bow ring-bolt and hitched around a midship thwart. It is well to have fifteen or twenty fathoms of spare line in the boat for use when close to the wreck, as this gives the people in the boat control of the situation at the time when too much or too little line may be of vital consequence. There should be three men in the boat (with life-belts on);—one man to handle the steering oar, one to handle the line, and one for bailing, signaling the ship, throwing the heaving line to the wreck, etc.—for there will be no moment during the rescue when either the steering oar or the line should be left unattended. A life-belt or buoy should be taken, in this case as in the one previously described, with two lines for hauling it back and forth between the boat and the wreck.

Oil-bags are hung from the quarters of the boat and oil used by the wreck, as in all cases of this kind. If the wreck cannot assist in this way, the rescuing vessel should pass along to leeward (at a good distance) running oil freely. The wreck will soon drift into the slick thus created.

The boat is dropped down by paying out line on board, being kept head to sea by the steering oar assisted by the drag of the line over the bow. The line must be kept in hand on board the ship, to insure a prompt response to signals from the boat. The officer in charge of the work keeps his glasses on the boat incessantly.

If the line is led through a midship chock on the ship and the ship allowed to fall off on a heading parallel with the wreck, she will drift with the latter, though perhaps not at an equal speed, and will change the distance very slowly if at all. She will, moreover, be perfectly free to handle the engines slowly—going ahead or backing as may be necessary to keep in position for giving the boat a lee. If the attempt is made to hold her up to the sea, it will be necessary to keep turning the engine ahead, which will result in drawing away from the wreck. There will, moreover, be constant danger of fouling the screw with the line, and no lee will be created for the boat.

A simple code of signals must be adopted and fully understood, thus:

In the Boat.

Right arm extended,	Slack away on board,
Left arm extended,	Haul in on board,
Arm held up overhead,	Hold on.

The arm waved, in either of these positions, emphasizes the order. Thus, the right arm extended and waved up and down means "slack away roundly."

On Board Ship.

A long blast of the whistle,	"We are about to haul in."

When the boat is near the wreck, say within thirty or forty yards, signal is made to hold on to the line on board, and the men in the boat begin to pay out, dropping down as close as is thought perfectly safe, then floating the life-belt across. This is picked up by those on board and worked as has already been described. When the boat is loaded, the signal is given and it is hauled back to the ship. Here the greatest care must be exercised and the line hauled in very slowly, else the boat is certain to be swamped.

If the weather is such that a boat cannot be lowered, the difficulties of effecting a rescue are greatly increased, but the situation is not necessarily hopeless. There are many ways of getting a line between the ships; as, for example, by a line-throwing gun, a rocket, or a float. If a balsa is available, the following method might give some hope: The rescuing vessel steams slowly across the stern of the wreck, towing the balsa by a very long line, and manœuvres in such a way as to cause the line (not the balsa) to foul the wreck. If the people on board can haul the balsa up to leeward and get on it there should be no great difficulty about saving them.

Another method which suggests itself is the following: Suppose it is apparent that the wreck is drifting faster than the rescuing vessel will drift if she stops her engines. The rescuing vessel goes to leeward and places herself, with engines stopped, in such a position that her stern is just clear of the line of drift of the stern of the wreck, and with her head pointed away from this line, so that if any miscalculation is made, a few turns of the screw ahead will carry her clear. As the wreck drifts down, a line is gotten across by any means that is convenient and the people are hauled across. If the rescuing vessel drifts the faster she will of course go to windward instead of to leeward, and wait to drift into position herself. In this way it should be possible without imprudence to let the vessels come much closer than would be safe in any other manœuvre that could be attempted.

The following extract from a letter received by the author gives a detailed description of several rescues by the writer of the letter, who is one of the most experienced officers of the International Navigation Company.[1] It will be noted that he believes in holding his ship as close as possible on the weather quarter of the wreck instead of going to leeward to pick up the boat; believing that more is gained by the lee afforded in this way than would be gained by the other plan.

> In December, 1899, I was in charge of the boat from the S. S. "Pennland" that rescued the crew of the British Brigantine "Don Juan," of Salcombe, England, in the North Atlantic. In the morning we discovered a vessel dismasted and rolling in the trough of the sea, the wind N.W., force about 7, and a very high sea. Getting closer to her, we saw that there were people on board of her. I got a volunteer crew and made the boat ready for lowering, taking in a couple of heaving lines, two buckets, and a large can of oil. The "Pennland" was brought to windward of the wreck close to and with the wind and sea about 4 points on the starboard bow, heading about west. The boat was lowered with the full crew, 8 men, in it and a bridle around the falls from the main deck to prevent the boat from swinging too much when lowered; a line from the fore part of the ship in the boat. The boat was lowered very quickly, and on touching the water the patent hooks disengaged themselves, the bow-line was passed aft and a strong pull on it brought the boat's bow around and sheered it clear of the ship's side. We got the oars out immediately and pulled before the wind and sea toward the wreck, having good shelter of our own vessel. When we got close to the wreck we found it impossible to get alongside, as she was rolling heavily, the sea washing over her, and part of her rigging floating alongside. We got close under her stern with the boat and had a line thrown us from the wreck; to this we bent on our heaving line and a life-belt, which was hauled to the wreck, one end being in the boat. The life-belt was put on the first man to go and the bight of the line secured around him under his arms; he jumped overboard and was pulled in the boat. The life-belt was hauled back to the wreck, and by this means all the crew, 9 in number, were rescued. Our vessel was drifting in the trough of the sea with the wreck, close to; so a short pull brought us safely alongside.

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[1] Captain H. Doxrud, Steamship Noordland.

During the rescue the boat's crew was placed as follows: two men in the bow to work the line, four men at the oars to keep the boat in position, one man bailing and myself steering (using a long oar instead of a rudder) and directing the work.

My second experience was in October, 1892, off the Flemish Cap—when Chief Officer of the S. S. *Noordland,* when I was in charge of the boat's crew that rescued the crew of the Norwegian Barque "Kong Oscar the 2nd." The wind was N.W., force about 6, with heavy hail squalls. This rescue was very difficult and dangerous, as it was done during a very dark night, and took from 9 in the evening until 1 in the morning. The *Noordland* was brought to, to windward of the wreck, heading about west, when the boat was lowered in the same manner as on the former occasion, with 8 men in it. We got safely away from the ship's side. Coming up to the wreck, we found her waterlogged, the sea making a clean sweep over her, making it impossible to get alongside. The crew, numbering 16, was taken off by means of a life-belt and line, as on the former occasion.

The *Noordland* was drifting in the trough of the sea to windward, and we pulled up to her under her lee and got safely alongside and on board with our boat load of men. The boat's crew during the rescue was placed as on the former occasion.

My third experience was in October, 1899, when in command of S. S. *Rhynland.* When off George's Bank we fell in with the disabled and waterlogged British Brigantine "Ida Maud." The night previous, it had been blowing a gale from the S.E.; and at the time (about 3 P. M.), it was blowing from N. W., force about 6, making a very nasty cross sea.

I brought the *Rhynland* to windward of the wreck, close to, heading about W.S.W., and lowered one of the port life-boats with a volunteer crew of 8 men, Chief Officer Daddow in charge. The boat got away from the ship all right and proceeded toward the wreck.

As on the former occasions, it was not possible to get alongside the wreck, the sea washing over her, and a lot of loose lumber floating about. A rope was thrown over the end of the main boom that extended several feet abaft the stern of the brigantine, the shipwrecked crew climbed out one by one to the end of the boom and dropped into the boat. In the meantime I had brought the "Rhynland" close to the wreck, her bow nearly in line with the stern of the wreck, thereby giving the boat shelter, and a short pull brought them alongside.

In these instances oil has been frequently used both from the rescuing vessel, the boats, and in the first instance from the wreck also, and I cannot recommend its use too strongly for work like this. Its effect is simply wonderful, and I attribute my success in the above cases without mishap greatly to a liberal and judicious use of oil.

CHAPTER XXIII.

MAN OVERBOARD.[1]

The most immediate danger to a man falling overboard from a steamer is that of being struck by the propeller. This danger is especially great in the case of a vessel with twin-screws, and is of course increased in any case by throwing the stern to the side on which the man has gone over.

If the experiment is tried of throwing over from the bow a light buoyant object, it will be found that by the time this reaches the stern it will be clear of the side by a considerable distance, being thrown off by the surface wash from the side. A *man* falling overboard may feel this wash to a certain extent, but he sinks in the beginning far below its influence and into the suction of the screw. Moreover, his first instinct is to swim back toward the ship.

The first thought of a man falling overboard should be to swim outward from the ship, and the first thought of the officer on the bridge should be to stop, *not back*, the engines. If it is known from which side the man has fallen, the helm may be put hard over to the opposite side, throwing the stern away from him. This calls for quick thinking and prompt action; but the time available is by no means as short as might be supposed. A steamer 400 feet long, making 12 knots, passes over her own length in twenty seconds. Thus, if a man falls overboard amidships, he will be ten seconds in reaching the screw.

One or more life-buoys should be thrown over at once. If a little presence of mind is exercised here, it is often possible to throw one of these very close to the man.

At the first alarm, a number of men (previously instructed), jump aloft to try to keep the man in sight; and as quickly as possible a quartermaster follows them with a good pair of binoculars.

The ordinary life-buoy is so small that often the man in the water cannot see it, and it is of little or no assistance to the

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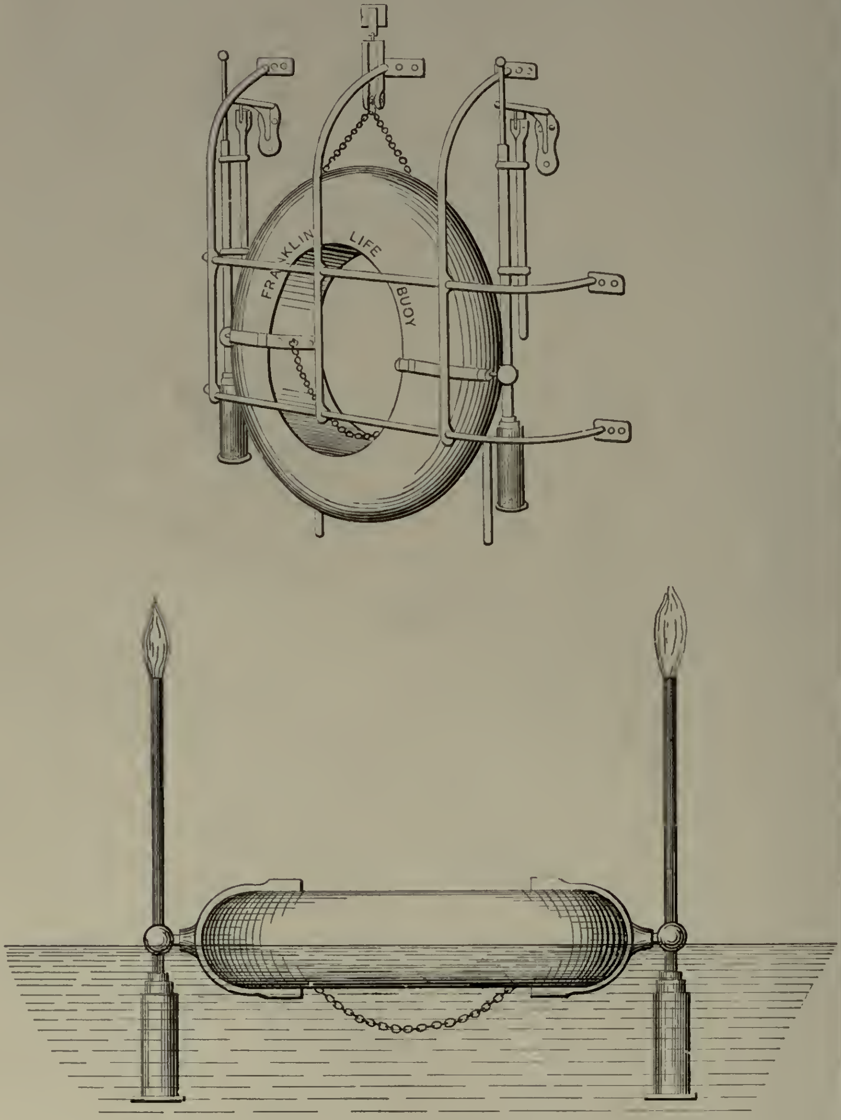
[1] For Man Overboard from a sailing ship, see Chapter "Manœuvring under Sail."

Plate No. 129.



LIFE BUOY, U. S. NAVY.

look-outs who are trying to keep him in sight. This is a serious and often a fatal defect. It is well to keep a number of these small light buoys about the decks, to be thrown overboard on the instant by any one who may be near them; but in addition to these, there should be provided a more elaborate buoy or float fitted with a mast and a light, to be let go promptly and to serve not only as a buoy, but as a *marker*.

If to this is added a can stuffed with oakum soaked in oil, a *slick* will be created around the buoy which will not only be of great help to the man but may assist greatly in keeping the spot in sight.

The light should be of a nature to ignite upon contact with the water. What is known as the "Holmes Light" is of this nature and is much used in the English merchant service. In the absence of a buoy fitted as above described (or in addition thereto), lights of this kind should be carried on the bridge (or forecastle), to be thrown over by the lookout, without an order, at the alarm of "Man overboard!"

This use of a marker, as distinct from the idea of a buoy (though preferably connected with the buoy) is of great importance.

Objection is sometimes made to the use of lights like the "Holmes" on the ground that the fumes given off by them are always offensive and in some cases unbearably suffocating. This is a reason for not connecting them rigidly with the buoy. They may, however, be attached to it by a short line which would let them float at some distance from it. Of course a light which ignites by contact with water must be sealed until it is wanted, when it may be punched or torn open either by a simple tool attached to it, as in the case of the "Holmes," or by some automatic arrangement connected with its release, as in the case of the U. S. Navy life-buoy.

Men-of-war usually carry life-buoys of special types, fulfilling more or less satisfactorily the above requirements. The type at present used in the United States Navy is shown in Plate **129**.

There seems no reason why a steamer should not carry at the end of the bridge (or on an outrigger if the bridge does not overhang the water), a small balsa, of a size sufficient to carry a man comfortably, fitted with a mast and a light and with two or three water-tight pockets containing a small supply of provisions and water, and, perhaps, a few lights of the Holmes or some similar type which could be used to attract the attention of passing vessels, in the event of being left adrift.

Under ordinary circumstances the engines are thrown to full speed astern as soon as the man is clear of the screw, and a boat is lowered as soon as the speed has been reduced sufficiently. The boat pulls back in search of the man, guided by signals from the lookouts aloft, provided they have succeeded in keeping the man or the buoy in sight. Failing this, the boat cannot go far wrong if it pulls back on a course *opposite the original heading* of the ship; for although the steamer in backing will probably throw her head to one side, she will not usually gain a great amount of ground in that direction before coming to rest.

In most conditions of the sea, a boat may be lowered with reasonable safety at a speed of five knots; and we may assume that the distance required to reduce the speed to this will be from two to four ship's lengths, and the time, from two to four minutes.

If the weather is smooth or the sea from such a direction that there is no occasion for manœuvring to lower the boat, all this is simple enough; but if conditions are such as to call for *turning* wholly or partially before lowering, it is thought by many officers a good plan to put the helm hard over, keeping the engines turning ahead, and to describe a circle, thus coming back, with the ship, to a point near that at which the man went over.

Observations upon the turning circles of a large number of steamers show that a steamer turning with hard-over helm will pass within a short distance—rarely so much as a ship's length—from the point where the helm was put down. No doubt the symmetry of the curve may be considerably modified by wind and sea, but not sufficiently to prevent a return to the neighborhood of the starting point. The time required for the full turn will vary with the length, the speed, the weather and the manœuvring powers of the vessel. Every officer should know the manœuvring powers of his own vessel, especially the size of the turning circle, the time required to describe it, and how close the ship will come to a marker thrown over just before putting down the helm.

Without attempting to lay down rules for the endless variety of situations which may arise in a matter of this kind, it will perhaps not be going too far to say that, generally speaking, the ship should be stopped and backed if she has the wind and sea ahead, or abeam, and that she would probably do well to turn, if they are much abaft the beam; since in the last case a boat pulling back would be working against wind and sea.

It will of course be understood that in turning, speed must be regulated according to the conditions of the weather. It would not do, for example, to come up into a heavy sea at full speed. (See Chapter "Handling a Steamer in Heavy Weather.")

If the conditions are such—due to the lack of a proper marker, or to fog, or to any other cause—that difficulty is to be anticipated in finding the man, it is probably better to stop and send the boat back along the course opposite the original heading. This emphasizes the importance of having a compass in the boat.

In case of fog, the vessel should avoid changing her position while the boat is away. The compass is thus a guide for finding the way back—assisted, of course, by sounding the whistle, firing guns, &c.

There can be no question that in weather too heavy to admit of lowering a boat, the one method that can give a hope of saving the man is to turn and attempt to pick him up with the ship.

CHAPTER XXIV.

STRANDING.

§ I.

The first impulse of an officer upon finding his vessel stranded is usually to throw the engines to full speed astern. This may be the right thing to do, but it is not always so. If the ship has struck a rock, the chances are that she will have a hole in her bottom, and to back off may result in sinking her without leaving time even for saving life. If aground on a soft bottom, to work the engines either way may result in disabling them by filling the condensers with sand or mud. Again, where a single screw steamer is aground forward, backing the screw may slew her stern around and put her on the beach throughout her full length. These are points which should be taken into consideration in deciding whether or not to back the engines immediately.

Assuming that, for whatever reason, it proves that the vessel cannot be backed off at once, the most urgent step to be taken is to lay out an anchor and get a good strain on a line from this, for holding the ship from being set farther up on the beach. Such a line, kept well taut, will sometimes start a ship off quite unexpectedly by the steady pull which it exerts;—a slight rise of the tide or a little working of the ship by the wind or sea, contributing toward the same end. As the laying out of a large anchor involves delay when every moment may be precious, it is well to send out a kedge at once, following this as soon as possible with a stream or a bower. If there is a current setting along the coast, as frequently happens, the anchor should be laid out a little off the quarter, to keep the stern from being swept around. A buoy with a good buoy-rope should be used on the anchor. While this work is in progress, careful soundings should be made around the ship on all sides, and a good leadsman stationed to note the rise or fall of the tide. The Tide-Tables, Sailing Directions, and Charts will of course be examined, the time of high water determined, and the direction of tidal currents noted. If there is a chance that help will be needed, no time should be lost in communicating with shore and making such arrangements as the situation calls for. The immediate assistance of a vessel large enough to carry out a heavy anchor may be of the greatest value. It may be possible to secure a fishing vessel for this.

An examination of the ship should be made as soon as possible after she strikes, and all compartments sounded. As already noted, this is particularly important on a rocky coast. If a compartment is found to be holed, the water-tight doors leading to it should be closed, the bulkheads braced, and the pumps put on, to keep the water down. If the hole is a large one, there will probably be danger in hauling off before stopping it at least in part.

When measures have been taken to prevent the ship from being set farther up the beach, *and not until then*, the work of lightening her may be begun;—ballast tanks pumped out, cargo shifted, lightered, or thrown overboard. If the ship is aground forward, something may often be gained by filling the after ballast tank or otherwise adding weight aft; as, for example, by shifting coal from an extreme forward to an extreme after bunker.

When conditions become favorable for backing and hauling off—which will of course be at high water—the chances of success will be greatly increased if the ship can be moved in her bed, either by rocking her from side to side or by slewing her stern a little. This may perhaps be done by means of a line to an anchor laid out on the beam or quarter.

Vessels have been worked loose from a sandy bottom by *going ahead* with their engines; the suction current drawn aft along the bilge acting apparently to scour out the sand.

If another vessel comes to your assistance, she should as a rule anchor to seaward of you, with a good scope of chain, get good lines from your stern, and heave these taut until she tails in toward you or as nearly so as the wind and tide permit. If she then starts her anchor windlass ahead and keeps full steam pressure on it, she will not only keep the lines taut, but will take in and hold every inch that is gained on the line between the ships. When the time comes for a combined effort to haul off, she starts her engines ahead, still keeping the anchor windlass in action.

It is a good plan for the assisting vessel to lay out her own spare anchors well off shore with good lines bent to them, and to send the ends of these lines on board the stranded vessel. These will be heavier than the anchors that the stranded vessel could conveniently lay out for herself, and can be placed to far better advantage. This does not interfere with any of the other methods of assisting that have been described.

Where the rise and fall of the tide are considerable, the assisting vessel may be anchored with a shorter scope and everything hove taut as above described, *at low tide*. As the tide rises, the buoyancy of the anchored vessel will put a tremendous force on the line. In a similar way, in cases where a strong current runs along the beach at certain stages of the tide, if the lines are hove taut at slack water, the current when it makes will be on the beam of the anchored vessel and will exert a powerful force, with all the advantage due to the span formed by the anchor cable and the tow-line. It would be well here for the assisting vessel to have two anchors down.

In all cases like the above, of attempts to pull a stranded vessel off, there is danger that if she comes off suddenly she will collide with the vessel that is assisting her. The latter should therefore be ready to slip everything and get out of the way.

There is one possible advantage which results from having the towing ship under way. This is that if she does not start the other vessel by pulling directly astern, she can place herself on the quarter and may thus be enabled to slew the stern of the stranded vessel and so loosen her up in her bed.

Generally speaking, however, the difficulties are increased if the assisting vessel cannot anchor. It is almost impossible for her to keep a steady tension on the line, under the most favorable circumstances; and if the wind or the current is across, there is great danger that she will swing around on the tow-line and end by going ashore herself.

See Chapter on Piloting, where it is explained that in many places the full strength of tidal current corresponds with high and low water.

The only thing to be done here is for the assisting vessel to lie off, head to the current, until all is ready; then to run the line, *taking it from one of her own chocks fairly well forward*—not under any circumstances from the stern. She then heads more or less across the current and goes ahead, putting the strain on

Plate No. 130.

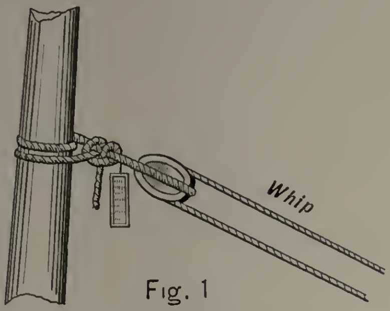


Fig. 1
Tail Block Hauled
off by first line from shore

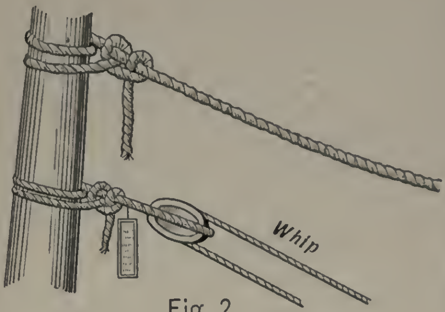


Fig. 2
Hawser Hauled off by Whip

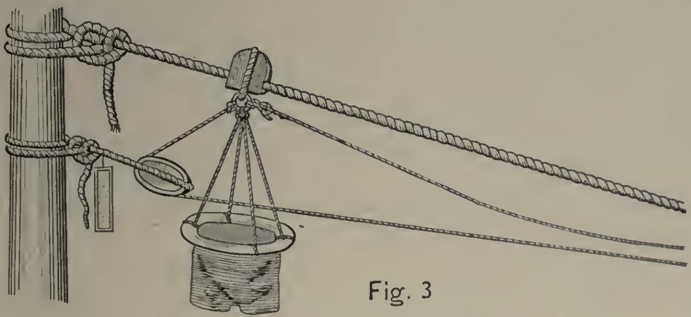


Fig. 3
Breeches Buoy.

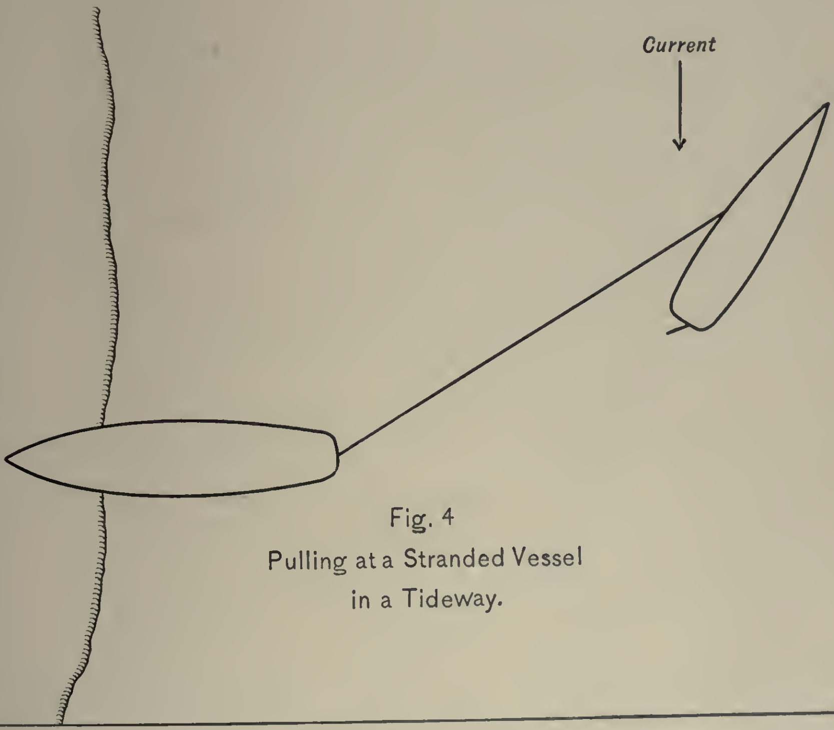


Fig. 4
Pulling at a Stranded Vessel
in a Tideway.

STRANDING

the line gradually and holding herself up against the tide by the helm, which will have good turning power because of the way the ship can pivot on the line (Plate **130**, Fig. 4). With the line led through a stern chock, the rudder would have no power, and the ship would be swept down helplessly toward the beach unless she cut the line. Even when manœuvring as above described, an axe should be at hand to cut if necessary.

There are, of course, many cases in which the effort to back off should be made immediately, as, for example, when it is known that the beach on which the ship has struck is hard and steep and not rocky. Here she will certainly be aground forward only, but there is great danger that she will swing around and ground throughout her whole length. And if this does not happen, the chances are that if there is any sea on she will be dangerously strained and perhaps broken in two. So here the one chance may be to back at full speed immediately;—not, however, neglecting other measures which do not interfere with it. If it is found that the backing is slewing her around broadside on, the engines must be stopped. This is very likely to happen with a single screw. On a beach of this kind, it is particularly important to get an anchor laid out immediately. A light kedge carried out at once on the quarter opposite that toward which she is inclined to swing around, may be of vital importance.

If all other methods fail, resort must be had to regular salvage operations, the description of which is beyond the scope of this book.

§II. INSTRUCTIONS TO MARINERS IN CASE OF SHIPWRECK.

All sea-faring people should be familiar with the following instructions, which are practically identical with those issued by all nations having Life Saving Services. It is the unanimous testimony of the employees of such services that the principal difficulties with which they have to deal arise from the failure of shipwrecked crews to cooperate intelligently in the work of rescue.

Instructions.

Rescue with the Life-Boat or Surf-Boat.

The patrolman, after discovering your vessel ashore and burning a Coston signal, hastens to his station for assistance. If the use of a boat is practicable, either the large life-boat is launched from its ways in the station and proceeds to the wreck by water or the lighter surf-boat is hauled overland to a point opposite the wreck and launched, as circumstances may require.

Upon the boat reaching your vessel, the directions and orders of the keeper (who always commands and steers the boat) should be implicitly obeyed. Any headlong rushing and crowding should be prevented, and the captain of the vessel should remain on board, to preserve order, until every other person has left.

Women, children, helpless persons, and passengers should be passed into the boat first.

Goods or baggage will positively not be taken into the boat until all are landed. If any be passed in against the keeper's remonstrance he is fully authorized to throw the same overboard.

Rescue with the Breeches-Buoy or Life-Car.

Should it be inexpedient to use either the life-boat or surf-boat, recourse will be had to the wreck-gun and beach apparatus for the rescue by the breeches-buoy or the life-car.

A shot with a small line attached will be fired across your vessel.

Get hold of the line as soon as possible and haul on board until you get a tail-block with a whip or endless line rove through it. This tail-block should be hauled on board as quickly as possible to prevent the whip drifting off with the set or fouling with wreckage, &c. Therefore, if you have been driven into the rigging, where but one or two men can work to advantage, cut the shot-line and run it through some available block, such as the throat or peak-halliards block, or any block which will afford a clear lead, or even between the ratlines, that as many as possible may assist in hauling.

Attached to the tail-block will be a tally-board with the following directions in English on one side and French on the other:

"Make the tail of the block fast to the lower mast, well up. If the masts are gone, then to the best place you can find. Cast off shot-line, see that the rope in the block runs free, and show signal to the shore."

The above instructions being complied with, the result will be as shown in Fig. 1, Plate **130**.

As soon as your signal is seen a three-inch hawser will be bent on to the whip and hauled off to your ship by the life-saving crew.

If circumstances will admit, you can assist the life-saving crew by manning that part of the whip to which the hawser is bent and hauling with them.

When the end of the hawser is got on board a tally-board will be found attached, bearing the following directions in English on one side and French on the other:

"Make this hawser fast about two feet above the tail-block, see all clear and that the rope in the block runs free, and show signal to the shore."

These instructions being obeyed, the result will be as shown in Fig. 2, Plate **130**.

Take particular care that there are no turns of the whip-line round the hawser. To prevent this take the end of the hawser UP BETWEEN *the parts of the whip before making it fast.*

When the hawser is made fast, the whip cast off from the hawser, and your signal seen by the life-saving crew, they will haul the hawser taut and by means of the whip will haul off to your ship a breeches-buoy suspended from a traveler-block, or a life-car from rings, running on the hawser.

Fig. 3, Plate **130**, represents the apparatus rigged, with the breeches-buoy hauled off to the ship.

If the breeches-buoy be sent, let one man immediately get into it, thrusting his legs through the breeches. If the life-car, remove the hatch, place as many persons into it as it will hold (four to six), and secure the hatch on the outside by the hatch-bar and hook, signal as before, and the buoy or car will be hauled ashore. This will be repeated until all are landed. On the last trip of the life-car the hatch must be secured by the inside hatch-bar.

In many instances two men can be landed in the breeches-buoy at the same time by each putting a leg through a leg of the breeches and holding on to the lifts of the buoy.

Children, when brought ashore by the buoy, should be in the arms of older persons or securely lashed to the buoy. Women and children should be landed first.

In signaling as directed in the foregoing instructions, if in the daytime, let one man separate himself from the rest and swing his hat, a handkerchief, or his hand; if at night, the showing of a light, and concealing it once or twice, will be understood; and like signals will be made from the shore.

Circumstances may arise, owing to the strength of the current or set, or the danger of the wreck breaking up immediately, when it would be impossible to send off the hawser. In such a case a breeches-buoy or life-car will be hauled off instead by the whip, or sent off to you by the shot-line, and you will be hauled ashore through the surf.

If your vessel is stranded during the night and discovered by the patrolman, which you will know by his burning a brilliant red light, keep a bright lookout for signs of the arrival of the life-saving crew abreast of your vessel.

From one to four hours may intervene between the burning of the light and their arrival, as the patrolman will have to return to his station, perhaps three or four miles distant, and the life-saving crew draw the apparatus or surf-boat through the sand or over bad roads to where your vessel is stranded.

Lights on the beach will indicate their arrival, and the sound of cannon-firing from the shore may be taken as evidence that a line has been fired across your vessel. Therefore, upon hearing the cannon, make strict search aloft, fore and aft, for the shot-line, for it is almost certain to be there. Though the movements of the life-saving crew may not be perceptible to you, owing to the darkness, your ship will be a good mark for the men experienced in the use of the wreck-gun, and the first shot seldom fails.

RECAPITULATION.

Remain by the wreck until assistance arrives from the shore, unless your vessel shows signs of immediately breaking up.

If not discovered immediately by the patrol, burn rockets, flare-up, or other lights, or, if the weather be foggy, fire guns.

Take particular care that there are no turns of the whip-line round the hawser before making the hawser fast.

Send the women, children, helpless persons, and passengers ashore first.

Make yourself thoroughly familiar with these instructions, and remember that on your coolness and strict attention to them will greatly depend the chances of success in bringing you and your people safely to land.

The following signals, approved by the International Marine

Conference convened at Washington in October, 1889, have been adopted by the Life-Saving Service, and will be used and recognized by the officers and employees as occasion may require:

"Upon the discovery of a wreck by night, the life-saving force will burn a red pyrotechnic light or a red rocket to signify—'You are seen; assistance will be given as soon as possible.'

"A red flag waved on shore by day, or a red light, red rocket, or red Roman candle displayed by night, will signify—'Haul away.'

"A white flag waved on shore by day, or a white light slowly swung back and forth, or a white rocket, or white Roman candle fired by night will signify—'Slack away.'

"Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and a red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify—'Do not attempt to land in your own boats. It is impossible.'

"A man on shore beckoning by day, or two torches burning near together by night, will signify—'This is the best place to land.'

"Any of these signals may be answered from the vessel as follows: In the daytime, by waving a flag, a handkerchief, a hat, or even the hand; at night, by firing a rocket, a blue-light, or a gun, or by showing a light over the ship's gunwale for a short time, and then concealing it."

CHAPTER XXV.

MAKING AND TAKING IN SAIL.

It is clear that something is gained in ease and quickness of handling a sail, both in setting and in taking in, if the sail is spilled; but to spill it means to let it shake, perhaps very violently, and the shaking of a large and heavy sail in a strong breeze is a very serious matter, involving danger not only of splitting the sail, but of springing the yard and possibly the mast. For this reason, in taking in a course or a topsail in a strong breeze, every precaution is used to prevent the sail from flapping, the lee clew being the first set and the last taken in—this for the reason that the lee clew sets much flatter than the weather one and, so long as it stands full, steadies the sail as a whole, in spite of the flapping of the weather clew. With a topgallant sail or a royal, shaking is not so serious a matter. Moreover, the yard must be clewed down at once (to relieve the mast) and this in itself spills the sail to a great extent; so here, in the case of a fresh breeze, we haul up the *lee* clew first, bracing in and clewing down at the same time. It is important to get the yard down as soon as possible, thus putting the strain upon the mast at the part which is best able to bear it. Hence we have the rule, "always clew down before clewing up." In a light breeze this is not of importance, and the general practice is, in taking in a light sail, to let go sheets and halliards together. Many officers, however, while using the conventional order "In topgallant sails," preface this with a caution to the mastmen to keep fast the weather sheets until the yards are down.

The weather braces are manned for taking in topsails and light sails, and the yards braced in and steadied as they come down. The rule is that the weather brace must be started in before the halliards are lowered, to prevent the yard from binding against the lee rigging. But if the yard is well up and the sheets taut, it may be impossible to brace in without first slacking a little on either the halliards or the lee sheet. It is a good plan to slack a little of both—just sufficient to admit of starting the brace, after which there should be no trouble in keeping the yard laid properly as it comes down. Evidently the difficulty about bracing in may be met by *luffing* sufficiently to "touch" the weather leech; but in clewing down to a squall, which is the case in which the difficulty most frequently arises, it may not be considered safe to luff. Indeed, the general custom is to keep away, and the effect of this is to increase, for the moment, the pressure on the weather leech.

In hoisting a sail, the lee brace is always left slack and the weather brace 'tended. The yard will brace itself if allowed to do so, and the sail should be kept lifting as it goes up.

To get the tack of a course down properly after the sail is set, it should be manned with a good force (or a jigger may be used) and the weather lift, the sheet, and the lee brace slacked. After getting the tack down, the other gear is hauled taut.

In taking in sails with the wind free, especially if it is abaft the beam, there is not so much trouble to be anticipated from shaking; so both clews are run up together, the buntlines being well manned at the same time. Here, as in other cases, the yards are clewed down before the sheets are started.

In making sail, the sheets are gotten home before the halliards are taut up, but not before the halliards are started. The sheets will go home more easily if the halliards are run up at the same time.

Care must be taken, in making sail, that the topsails are not dropped on top of the men on the lower yards, as they will be if the clewlines are let go before the men lay in. The clewlines should never be let go by the run, but eased down, giving the sheets a clear lead from the sheave in the lower yard to the block on the sail and preventing them from sawing across the edge of the sheave.

When topsails, topgallant-sails, and royals are set, their lifts hang forward of the sails. If allowed to hang down abaft, they would be in danger of fouling as the yards are lowered, and would be in the way of men going on the yards.

In laying a yard for furling or reefing—on the wind—it should be pointed nearly to the wind, but with a slight tendency for the sail to fill. A sail flat aback is almost impossible to handle. The braces should be taut and all the gear hauled up and belayed before the men go on the yard. If it becomes necessary to start anything afterward, the men should be required to lay in. If it proves that the yard has not been laid exactly right, a touch of the helm will probably correct it.

Before loosing a sail with the wind forward of the beam the yard should be pointed to the wind, or as nearly so as circumstances permit, care being taken not to bind the bunt of a course against the stay. This is a case which often arises in making sail on a steamer.

In setting a jib or staysail, the sheet is first hauled aft to steady the sail, then eased off as much as may be necessary as the halliards are run up. In taking in, the sheet is kept fast as the halliards are let go, but eased away when the hanks begin to bind as the sail comes down.

Similarly, the foot of a trysail is set before the head, and taken in after it.

The vangs on a trysail gaff should be let go before hauling out the sail, their only office being to steady the gaff when the sail is not set. Schooners usually have no vangs.

It should not be forgotten that for making and taking in sail, the gear which is to be attended is quite as important as that which is manned.

To Set the Foresail, by the Wind.

If the yard is square, brace it up, but not so sharp as to jam the bunt of the sail under the forestay. If it is already sharp up, it will probably need bracing in a little to clear the stay.

Lay aloft and loose the foresail! Man the foretack and sheet!

When ready,

Let fall! Lay in! Lay down from aloft! Let go and overhaul the rigging! Haul aboard!

To get the tack well down, the sheet, the lee brace, the weather lift and the weather topsail clew-line should be slacked, and hauled taut again after the tack is down. The lee main brace has a downward lead and directly opposes the tack. The fore brace may lead on a line with the yard, but if not, slacking it helps more or less in boarding the tack.

In a strong breeze, the sail may be set in the same way, provided the force available is sufficient to run the tack and sheet home without allowing time for the sail to shake. But under ordinary circumstances, as when working with the watch, it is better to set one clew at a time, the lee clew first. Man the gear as before, but with most of the force on the sheet. Then,

Ease down the lee clew-garnet! Haul aft! Ease down the weather clew-garnet! Haul aboard!

The buntlines are let go as the lee clew-garnet is eased down.

See that the buntwhip and leech lines are well overhauled before starting anything else.

To Take in the Foresail.

Man the fore clew-garnets and buntlines! Hands by the fore tack and sheet and fore bowline!

When ready,

Haul taut! Up foresail!

If blowing fresh, the sail may be taken in in the same way, provided the force is sufficient to run it up without shaking. But in most cases the weather clew should be run up first—after checking a fathom or so of the sheet.

Man the gear as before, but with most of the force on the weather clew-garnet. Then,

Check a fathom of the fore sheet! Ease away the fore tack and bowline! Haul up to windward!

Ease away the sheet! Haul up to leeward!

The buntlines are run up with the weather clew-garnet.

Before starting the tack, haul taut the lee lift, as otherwise the downward sag of the lee yard-arm might split the leech of the topsail.

In setting the foresail with the wind aft or on the quarter, both sheets are manned, the orders being:

Man both fore sheets! Lay down on the fore yard to overhaul the gear!

Haul taut! Clear away the rigging! Down foresail!

The mainsail is set in the same way as the foresail.

With the wind aft or nearly so, the mainsail is not set, as it would becalm the foresail. With the wind quartering, the lee clew of the mainsail is carried, all the gear except the weather clew-garnet being overhauled.

The topsails are usually carried whenever the ship is under sail, being set and taken in when getting underway and coming to anchor. There are, however, exceptional circumstances under which it may become necessary to take them in and set them at sea.

To Set a Topsail on the Wind.

The yard is first braced up as much as the topmast rigging permits.

Lay aloft and loose the fore topsail! Lead along and man the topsail sheets and halliards!

See all the gear, including the braces, clear for running.

When the sail is loosed,

Let fall! Lay in! Lay down from aloft!

Let go and overhaul the rigging! Tend the braces! Set taut! Sheet home and hoist away the topsail!

The order to sheet home is sometimes given immediately after "Let fall." This would be dangerous if there were men on the lower yards, and the better way is to give the orders as above in all cases.

The clew-lines should always be eased down instead of being let go by the run. This gives a clear lead for the sheets through the sheaves in the lower yard-arms.

The sheets will go home better if the halliards are started up at the same time. The lee brace is let go altogether and the weather brace tended and slacked off slowly as the yard goes up. The weather yard-arm will go forward of itself to the sharp-up mark unless the breeze is light, in which case a few hands may be put on the lee brace after the yard is hoisted.

In hoisting a topsail before the wind or nearly so, both braces should be slack.

In a strong breeze, the lee clew is set first. In this case the gear is led out as before, but the whole force is put on the lee sheet, with instructions to jump across to the weather sheet as soon as the lee one is home. Then,

Ease down the lee clew-line! Haul home the lee sheet!

Ease down the weather clew-line! Haul home the weather sheet!

All hands then man the halliards, and the sail is hoisted as before.

To Take in a Topsail.

Man the fore topsail clew-lines and buntlines! Weather fore topsail brace! Hands by the sheets and halliards!

Haul taut! Round in the weather brace! Settle away the fore topsail halliards! Clew down!

When the yard is on the cap,

Clear away the topsail sheets! Clew up!

In a strong breeze, the weather clew is hauled up first but the yard will be relieved by checking a little of the lee sheet first of all. In this case both clew-lines must be manned as before to clew the yard down, but the weather clew-line should be manned more strongly than the lee one. Then,

Check a little of the lee sheet! Round in the weather brace! Settle away the topsail halliards! Clew down!

Ease away the weather sheet! Clew up to windward!

Ease away the lee sheet! Clew up to leeward!

The buntlines are run up with the weather clew-line.

The sheets are always eased away, not let go.

The topsails are sometimes clewed down to a squall without being clewed up. To steady the sail, the buntlines are hauled up and the reef-tackles hauled out.

When shortening sail in coming to anchor, the topsails are often clewed up before the halliards are lowered. In this case, clew-jiggers are used instead of clew-lines, hauling the sails up forward of the yards. The braces are then manned fore and aft, the topsail yards lowered, and all yards squared at the same time.

The orders are:

Man the topsail clew-jiggers and buntlines!

When all is ready, the helm is put down for rounding to.

As the topsails lift,

Clear away the topsail sheets! Clew up!

When the sails are clewed up,

Man the weather head and main and lee cross-jack braces!

Settle away the topsail halliards! Square away!

To Set a Topgallant Sail.

Lay aloft and loose the fore topgallant sail!

Man the fore topgallant sheets and halliards! Tend the braces!

When ready aloft,

Let fall! Sheet home and hoist away the fore topgallant sail!

To Take in the Topgallant Sails.

Man the topgallant clew-lines and buntlines! Weather topgallant braces! Lay aloft and stand by to furl the topgallant sails!

When manned,

Haul taut! In topgallant sails!

In a fresh breeze, the lee clew is hauled up first.

Man the topgallant clew-lines and buntlines! Weather topgallant braces! Lay aloft and stand by to furl the topgallant sails!

Caution the mastmen to keep fast the weather sheets until the yards are down.

Round in the weather topgallant braces! Clear away the lee sheet and halliards! Clew down! Clear away the weather sheet! Clew up!

To Set the Royals.

Lay aloft and loose the royals! Man the royal sheets and halliards! Tend the braces!

When ready,

Let fall! Sheet home and hoist away the royals!

To Take in the Royals.

Man the royal clew-lines! Weather royal braces! Lay aloft and stand by to furl the royals!

Haul taut! In royals!

The royals and the flying jib are usually set and taken in together. For this the orders are,

Lay aloft and loose the royals! Lay out and clear away the flying jib! Man the royal sheet and halliards! Flying jib halliards!

Haul taut! Sheet home and hoist away the royals and flying jib!

For taking them in,

Man the royal clew-lines! Weather royal braces! Flying jib down haul!

Haul taut! In Royals! Down Flying jib! Furl the royals! Stow the flying jib!

It is a good plan for the officer of the watch at night under sail, to put into effect a private station bill of his own, for getting in light sails in a hurry. For this the men are told off *personally*, in little groups, to the individual ropes;—clew-lines, buntlines and weather braces,—and are required to remain close to the gear which they are to man; sitting or lying down, and even sleeping if the weather is not threatening, *but every man close alongside of the rope to which he has been told off.*

To Set the Jib.

Lay out and clear away the jib! Lead along and man the jib halliards!

The sail is loosed and thrown clear to leeward, the sheet hauled aft and tended. Then,

Clear away the down haul! Hoist away!

A few hands run away with the slack of the halliards, the others standing by to tail on. The sheet is eased away as the hanks begin to bind.

The flying jib and staysail are similarly set.

To Take in the Jib.

Man the jib downhaul!

Clear away the halliards! Haul down!

A few hands run away with the slack of the downhaul, the others standing by to tail on. The sheet must be eased away as the sail comes down.

To Set a Trysail.

Lay up and clear away the main trysail!

The sail is loosed and the sheet hooked.

Man the trysail sheet and head outhaul! Let go the weather vang!

Clear away the brails! Haul out!

If blowing fresh, the sheet is hauled aft before the head is started out.

A spanker is set in the same way, but the weight of the boom must first be taken on the weather topping-lift, the lee topping-lift being overhauled.

To Take in a Trysail or Spanker.

Man the trysail brails and head downhaul!

Let go the head outhaul! Haul down! Clear away the sheet! Brail up!

If a clew-rope is used, it is run up as soon as the head is hauled down, the slack of the brails being gathered in with the head. The brails cannot be hauled in snug until the clew-rope is up. Haul the boom amidships before starting the gear, to prevent the sail from binding against the lee mizzen rigging. Man the lee brails best, to spill the sail.

To Set a Gaff-Topsail.

The sail is sent up to windward with a stop around the sail and halliards just below the upper yard-arm. A hand stationed aloft keeps the yard clear, and cuts the stop at the proper time. The slack of the sheet is taken in as the sail goes up and the sheet is hauled home as soon as the stop is cut. The tack is held on at the proper point (indicated by a mark), and the halliards are run up as soon as the sheet is home. The tack is then dipped to leeward of everything and trimmed down. The tack of a gaff-topsail must be dipped in going about. In taking it in, it is hauled down to windward. If the sail sets with hoops on the mast, it is of course furled aloft, at the lower masthead.

Reefing Topsails.

The topgallant sails are taken in if set. They may be set again after hoisting the topsails, if only a single reef is taken. The topsails are clewed down, the reef-tackles hauled out and the buntlines hauled up. If on the wind, the yards are braced in as they are clewed down, and pointed as nearly to the wind as possible. The courses remain set, and are kept full enough to keep the ship under good control.

It is very important to get the yards properly laid, with the braces taut, and to have the reef-tackles hauled out, before the men are allowed to lay out on the yard; and care should be taken that the gear is not touched again until they are on the yard.

In bracing in the yard to clew down when blowing fresh, the pressure on the weather leech is much relieved by luffing sufficiently to lift the leech slightly, but this calls for great care, as the ship will have a tendency to come into the wind, and may catch aback. The pressure may also be relieved by running off, but the benefit of this will not be felt until she has gone off one or two points, and if it is blowing fresh, it may be difficult to make her go off at all.

It is always safer, of course, to run off than to luff, but it is not necessarily more seamanlike; provided, always, that proper care is used in luffing. It will be easier to start the weather brace if a little of the lee sheet is slacked.

In reefing with the wind aft or on the quarter, the yards remain square and the sail full. If the breeze is so strong that the earings cannot be hauled up in this way, the yards may be braced sharp up *into the wind;* that is to say, if the wind is on the starboard quarter, the yards are braced by the starboard braces. If this is not enough to spill the sails, a little port helm may be used.

To Reef Topsails by the Wind.

Man the topsail clew-lines, reef-tackles and buntlines! Weather topsail braces! Hands by the topsail halliards!

When the gear is manned,

Round in the weather topsail braces! Settle away the topsail halliards! Clew down!

It will probably be necessary to settle a little of the halliards before the weather brace can be started in, but this should be very little. As the brace has a downward lead, lowering the yard slacks the weather brace and allows the weather yard-arm to go forward, causing the lee yard-arm to bind with a heavy pressure against the lee rigging. As already remarked, the pressure on the weather leech may be relieved by luffing carefully; and if the halliards and the lee sheet are slacked a little at the same time, the yard should come in without difficulty. If proposing to run off, put the helm up, take in the spanker, slack the main sheet, and put all hands on the weather *main* topsail brace. The fore topsail remaining full will help her off and with all hands on the main topsail brace, the yard must come in.

The yard is clewed down on the cap and carefully laid, the sail being kept just lifting. Then,

Haul out the reef-tackles! Haul up the buntlines!

Stand by to lay aloft topmen!

Aloft topmen!

Lay out and take one reef!

The men on the yard gather up the sail and, facing to leeward, light the slack well over to windward while the weather earing is being passed. This being done, they "haul out to leeward" for passing the lee earing. The points are passed last of all.

In the meantime, the topsail halliards are manned on deck. When all is reported ready aloft,

Lay in! Lay down from aloft!

When the men are clear of the yard,

Let go and overhaul the rigging! Tend the braces! Hoist away the topsails!

TO PASS A REEF EARING. (Plate **33**.)

The cringle is hauled well up on the yard and the earing passed out over the first cleat of the coxcomb, down abaft the yard and up through the cringle. One turn may then be taken around the yard outside the cringle, to jam the parts coming from the cleat. The *bight* is then taken up through the cringle, and the end passed down around the yard up abaft and through the bight, which, with the cringle, is hauled well up on the yard. A number of turns are then passed through the cringle and around the yard and the end hitched to the lift.

If in passing the bight of the earing through the cringle as above described, a turn is taken *around the cringle*, the next turn of the earing (through the bight) will haul the sail well up and hold it there. This plan, although not usual, is to be recommended.

The other reefs, except the last, are passed in the same way, except that the outer turns go over the outer cleats of the coxcomb.

The close reef is hauled up snugly *under* the yard instead of on top, the first turn of the earing being passed around the yard from aft forward over the cleat.

When topsails are fitted with French reefs (jackstays and beckets), bull-earings are commonly used. These are fixtures on the yard instead of the sail and are fitted and passed as in Plate **33**.

TO SHAKE THE REEFS OUT OF THE TOPSAILS.

The yards are braced in and the halliards settled sufficiently to relieve the strain on the earings. The reef-tackles are then hauled out and the buntlines pulled up, after which the men are sent aloft and the reefs turned out—the points being cast off before the earings are eased away.

Stand by to Shake the Reefs out of the Topsails!

Man the topsail clew-lines, buntlines, and reef-tackles!

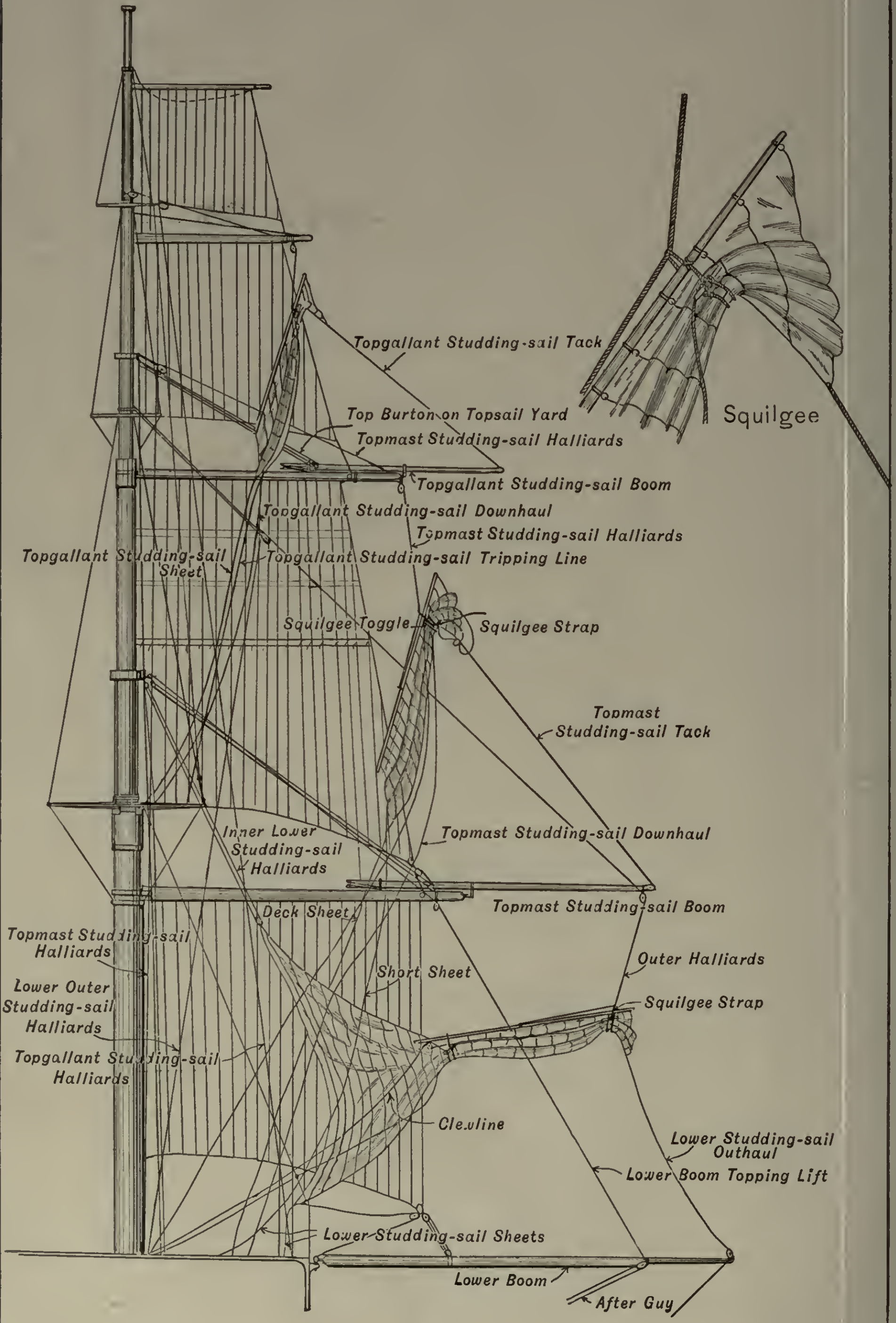
Round in the weather braces! Settle a little of the topsail halliards!

Haul out the reef-tackles! Haul up the buntlines!

Lay aloft and turn the reefs out of the topsails!

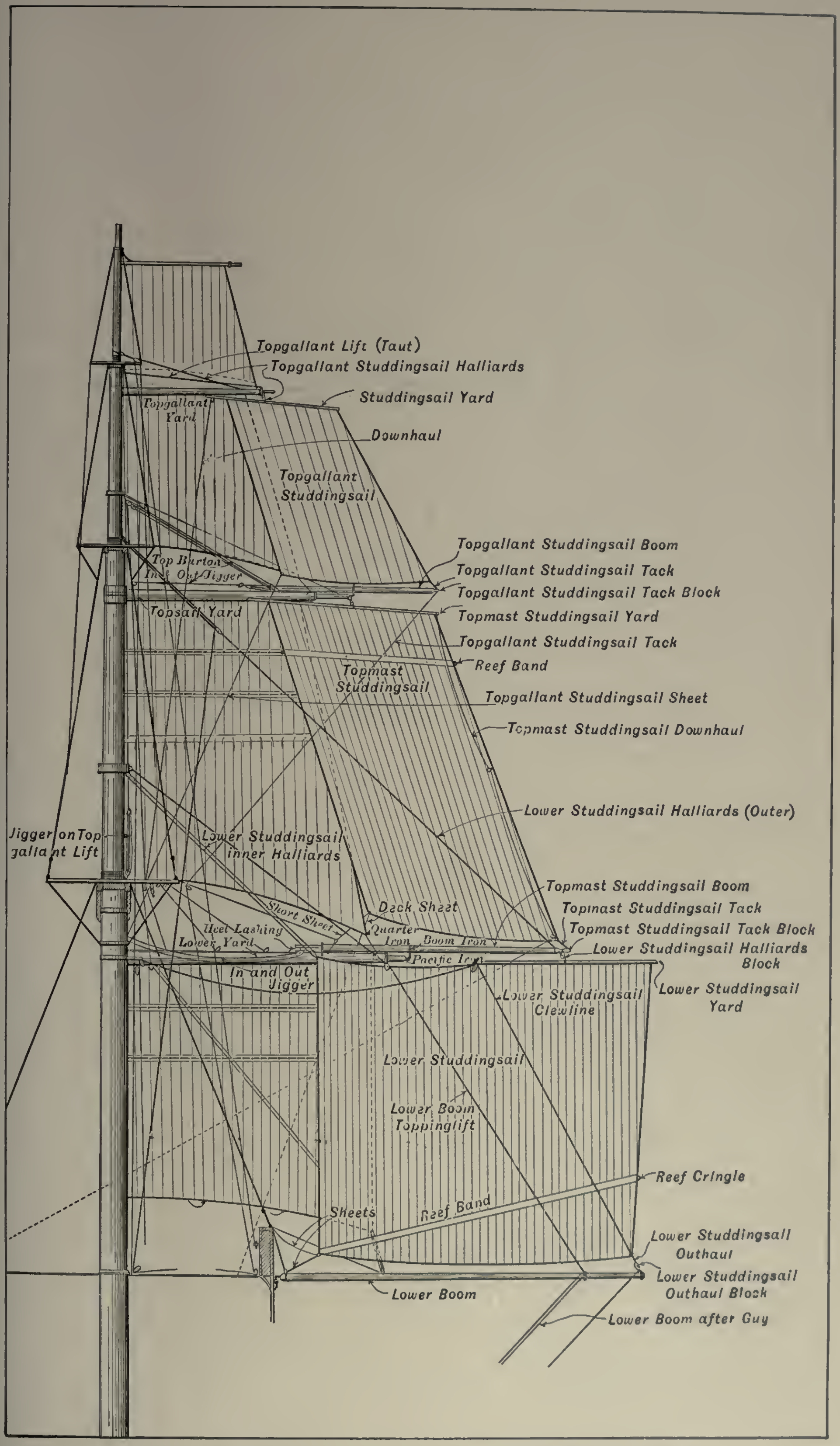
Lead along the halliards, but be careful that they are not taken off the pins. See the gear tended.

Plate No. 131.


Topgallant Studding-sail Tack
Squilgee
Top Burton on Topsail Yard
Topmast Studding-sail Halliards
Topgallant Studding-sail Boom
Topgallant Studding-sail Downhaul
Topmast Studding-sail Halliards
Topgallant Studding-sail Sheet
Topgallant Studding-sail Tripping Line
Squilgee Toggle
Squilgee Strap
Topmast Studding-sail Tack
Inner Lower Studding-sail Halliards
Topmast Studding-sail Downhaul
Deck Sheet
Topmast Studding-sail Boom
Topmast Studding-sail Halliards
Outer Halliards
Lower Outer Studding-sail Halliards
Short Sheet
Squilgee Strap
Topgallant Studding-sail Halliards
Clewline
Lower Studding-sail Outhaul
Lower Boom Topping Lift
Lower Studding-sail Sheets
Lower Boom
After Guy

SETTING STUDDING-SAILS

Plate No. 132.


Topgallant Lift (Taut)
Topgallant Studdingsail Halliards
Studdingsail Yard
Topgallant Yard
Downhaul
Topgallant Studdingsail
Topgallant Studdingsail Boom
Topgallant Studdingsail Tack
Topgallant Studdingsail Tack Block
Top Burton
In & Out Jigger
Topsail Yard
Topmast Studdingsail Yard
Topgallant Studdingsail Tack
Reef Band
Topmast Studdingsail
Topgallant Studdingsail Sheet
Topmast Studdingsail Downhaul
Lower Studdingsail Halliards (Outer)
Jigger on Topgallant Lift
Lower Studdingsail inner Halliards
Topmast Studdingsail Boom
Deck Sheet
Topmast Studdingsail Tack
Short Sheet
Heel Lashing
Quarter Iron
Topmast Studdingsail Tack Block
Lower Yard
Boom Iron
Lower Studdingsail Halliards Block
Pacific Iron
In and Out Jigger
Lower Studdingsail Clewline
Lower Studdingsail Yard
Lower Studdingsail
Lower Boom Toppinglift
Reef Cringle
Sheets
Reef Band
Lower Studdingsail Outhaul
Lower Studdingsail Outhaul Block
Lower Boom
Lower Boom after Guy

ALL STARBOARD STUDDINGSAILS SET.

When ready for easing away the earings,
Stand by! Ease away!
Lay in! Lay down from aloft!
When the men are clear of the yard,
Let go and overhaul the gear! Hoist away the topsails!

STUN'SAILS.

For carrying stun'sails, the topgallant yard is supported by getting a jigger on the lift and hauling taut the royal clew-line; the topsail yard by a burton from the topmast cap to a strap well out on the yard-arm. The topmast stun'sail boom is rigged out and in by a jigger on the lower yard, the topgallant stun'sail boom by the tricing-line rigged as a jigger on the topsail yard. Both booms are secured, when out, by heel-lashings. The topmast stun'sail boom is supported from aft by a "boom-brace" leading to the main rigging. When the topmast stun'sail is to be carried in a fresh breeze without the lower stun'sail, a "jumper" is rigged by seizing a toggle into the lower stun'sail halliards above the boom and hauling taut the lower end on the forecastle.

The topgallant stun'sail is carried abaft the leech of the topgallant sail, although the inner yard-arm may be dipped forward if the sail is carried with the wind on the other quarter. The topmast stun'sail is sent up abaft all, and the deck sheet trimmed down abaft; after which the short sheet leading to the top is rove and hauled taut. The end of the deck sheet is then bent to the downhaul and both are hauled up to the yard-arm and sent down forward.

The topgallant stun'sail sheet and downhaul are usually manned and tended in the top; but for taking in the sail in a fresh breeze, especially if the wind is well forward, a better lead for the downhaul is through the lubber's hole to the deck. In making up the sails for setting, they are gathered up to the yard and secured there by a strap and "squilgee" as in Plate **131**. As the strap is passed around the halliards also, it serves to keep the yard up and down as it is swayed aloft. The squilgee has a tripping line leading to the top by which it is pulled out when the sail is clear for setting (Plate **131**). With a topmast or a topgallant stun'sail, the tack is hauled out first, then the halliards gotten well up, and finally the sheets trimmed down.

In setting a lower stun'sail, the inner halliards are pulled well up, then the outer halliards and outhaul are manned and the sail is hauled out until about half way between the boom and the yard, when the squilgee is pulled out, the outer halliards run up, and the outhaul hauled out. In this case the halliards are pulled taut up before getting home the outhaul, as, if the order were reversed it would be necessary to lift the whole weight of the boom for getting the halliards up.

In taking in a topgallant stun'sail, the sheet and downhaul are manned and the halliards eased away before starting the tack. When the body of the sail has been gathered well abaft the leech of the topgallant sail, the tack is eased away and the yard hauled down.

In taking in a topmast stun'sail, the outer yard-arm is hauled well down to the boom-end, before starting the tack.

Men are stationed on the lower and topsail yards in setting and taking in stun'sails, to attend the booms and bear the sails clear.

In taking in a lower stun'sail, the outhaul is started first and the tack hauled up by the clew-line to the inner yard-arm. The outer halliards are then slacked, the inner halliards and the clew-line pulled up, and the sail comes in on the forecastle.

To Set a Topgallant Stun'sail.

Get the (fore) topgallant stun'sail ready for setting!

The gear being manned and all reported ready aloft,

Haul taut! Rig out! Hoist away!

The slack of the tack is taken in as the sail goes up. When the sail is well above the topsail yard and clear of the brace-block,

Out Squilgee!

Get the tack home, the halliards up, and finally trim down the sheet.

To Set a Topmast Stun'sail.

Get the (fore) topmast stun'sail ready for setting!

The gear being manned and everything ready,

Haul taut! Rig out! Hoist away!

The sail is swayed aloft, being guided clear by a man on the lower yard. When it is about half-way between the boom and the topsail yard,

Out Squilgee!

Haul out the tack, get the halliards up, trim and shift the sheets as has been described.

To Set a Lower Stun'sail.

Get the (starboard) lower stun'sail ready for setting!

In addition to the preparations already described, the lower boom topping-lift must be overhauled down and hooked to its place on the boom. The forward guy is manned (by a few hands only), and the after guy tended. The lower halliards are pulled well up.

When all is ready,

Haul taut! Top up!

Rig out!

Hoist away! Haul out!

When the sail is about half-way between the boom and the yard,

Out Squilgee!

Get the halliards up, the outhaul out, and trim down the sheets.

To Take in a Lower Stun'sail.

Stand by to take in the lower stun'sail!

Man the inner halliards, clew-line, and sheet, and tend the outhaul and outer halliards.

Ease away the outhaul! Clew up!

When the clew-line is up,

Lower away! Haul in!

Man the after guy! Tend the topping-lift and forward guy!

Haul taut! Rig in!

Unbend and trice up the gear and make up the sail.

To Take in a Topmast Stun'sail.

Stand by to take in the topmast stun'sail!

Man the downhaul, deck sheet and in-and-out jigger.

Tend the halliards, tack, and short sheet.

Lower away!

The yard is hauled down nearly to the boom end, the tack being kept fast. Then,

Haul down! Rig in!

The tack is started, the sail hauled down, and the boom rigged in. The burton is then taken off the topsail yard.

To Take in a Topgallant Stun'sail.

Stand by to take in the (fore) topgallant stun'sail!

Man the sheet and downhaul. Tend the tack and halliards.

Lower away! Haul down! Rig in!

Keep fast the tack until it is certain that the sail will not make trouble by getting forward of the topgallant sail.

Take the jigger off the topgallant lift!

BENDING SAIL.

Making up for Bending.—A topsail (single). The sail is stretched along the deck, after side down, and the second reef-band is brought up to the head and stretched taut along. The leeches as far as the reef-tackle cringles are then brought in along the head and the clews carried up over the head and thrown out clear. The buntline toggles are next taken up between the clews a little above the head of the sail and also thrown out clear.

The sail is then gathered up as in furling, by men ranged along the head, and the gaskets passed snugly around it. Finally, the clews are taken down forward of the bunt and up under the quarters where they are stopped to the head of the sail abaft. Thus the sail is made up as it would be furled after bending, except that the second reef-band is stretched taut along the head. The object of this is to furnish a cringle for hooking the yard-arm tackle without using the head-earing cringle, which is thus left clear for passing the turns of the earing after the sail is hauled out to the yard-arm. The clews, bowline and buntline toggles and head-earings are left out so that they can be gotten at without loosing the sail. The head-earings are stopped along the sail toward the bunt, and the reef-earings are knotted to the cringles next above their own.

Courses are made up in much the same way as topsails, the first reef-band, instead of the second, being taken up to the head.

With double topsails, the head is stretched taut along and the first reef-band brought up and stopped to the head-earing cringle. The sail is then rolled up and stops are passed around it, the clews and head-earings being left out.

To Bend a Topsail.—The sail is sent up by a top-burton hooked at the collar of the topmast stay, the lower block of which is overhauled down and hooked to a strap seized to the head-rope of the sail amidships and passed around the bunt as shown in Plate **43.** The buntlines may be bent on deck and hitched around the quarters of the sail, where they are helpful as taking the weight when hauling out along the yard. The reef-tackles are overhauled down to the top-rim and hooked there ready for use as yard-arm jiggers.

The sail is swayed up well above the yard, bringing the head-earings and reef-cringles within reach of the men in the top, who slue the turns out of the sail, hook the buntwhip, bend the sheets and clew-lines, and hook the reef-tackles in the second reef-cringles for hauling out. When all is ready, the sail is hauled out and "brought to" the yard, the burton being lowered and the weight of the quarters taken by the buntlines. The midship-roband is passed first, the earings next, and then the other robands; the sail being cast adrift to admit of getting the head taut along the yard. Care must be taken to get the midship roband fair with the midship point of the yard. The bowlines are toggled, the reef-tackles shifted to their proper cringles, and the sail set, if circumstances permit, to make sure that everything is clear.

TO BEND A COURSE.—A sail tackle may be used as in the case of a topsail, or the sail may be sent up by the buntlines; which, if used for this purpose, are toggled in their places, taken around the bunt of the sail on the bight, and hitched around their own standing parts. The reef-tackles are used for yard-arm jiggers and are assisted in hauling out the sail by the leech-lines, clinched to their cringles and stopped to the head of the sail at the proper points. The buntwhip is hooked before starting the sail from the deck.

The sail is swayed up and bent like the topsail. The tacks and sheets are triced up by the clew-garnets and shackled in place, and the sail is set to make sure that everything is clear.

TO BEND A JIB.—The jib is made up on the foot and secured by a strap passed around the body of the sail. The halliards and outhaul are hooked to this strap, and the sail swayed out to its place on the boom. The tack is passed, the halliards and downhaul shifted to the head cringle, the luff seized to the hanks on the stay, and the sheets bent.

The following is the routine of bending sail on a man-of-war.

It is supposed that the sails are made up and in place for sending aloft. Call,

Bend sail!

When ready,

Stand by to lay aloft sail loosers!

Aloft sail loosers!

The sail-burtons are hooked and sent down; buntlines, bunt-whip, leech-lines, and reef-tackles, overhauled, and all preparations made aloft for receiving the sails. The jib-halliards and downhaul are hooked to the strap around the jib, and the spanker gaff is lowered or a whip hooked under the top for tricing up the head of the spanker.

Man the sail-burtons and buntlines! Sway aloft!

The sails are swayed up well above the yards, and the yard-arm jiggers hooked and manned.

Stand by to lay aloft topmen! Aloft topmen!

Lower yardmen on the sheerpole! Aloft lower yardmen!

When the men are up and all is reported ready,

Haul out! Lay out and bring-to!

In a ship with stun'sail booms, these must be triced up.

If the sails are to be furled at once, the buntlines are pulled up and the order given:

Furl away!

If the sails are to be set, the orders are,

Man the topsail sheets and halliards! Jib halliards! Tend the braces!

Lay in! Lay down from aloft!

Let go and overhaul the gear!

Sheet home and hoist away the topsails!

Clear away the downhaul! Hoist away the jib!

When the topsails are up,

Man both fore and main sheets! Spanker outhaul!

Let go and overhaul the rigging! Down courses!

Clear away the brails! Haul out!

The light yards are gotten out of the rigging and landed in the gangways, where the sails are bent and furled.

The flying-jib is sent out and bent like the jib.

To Unbend a Topsail.—The sail being furled, the buntlines are hitched around it just outside the bunt and hauled taut to take the weight. The robands and head-earings are cast off, but a turn is kept with the earings until the order to ease away. For keeping the topsail clear of the lower stay, it is

Plate No 133.

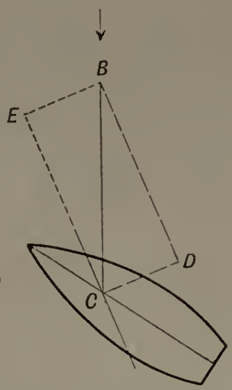


Fig. 1

1 *B C = Force and direction of wind (apparent.)*
D C = Effective component of wind's force. perpendicular to sail.

C D = Effective component of wind force upon sail.
2 *C E = Longitudinal component of C D propelling ship along keel line.*
G C = Lateral component of C D tending to force the ship to leeward, and creating a turning moment about the center of rotation.

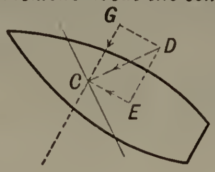


Fig. 2

3 *M O = Force and Direction of water pressure on rudder (helm to port.)*
N O = Effective component of M O perpendicular to rudder area.

(*a*)

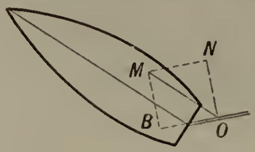


Fig. 3

(*b*)

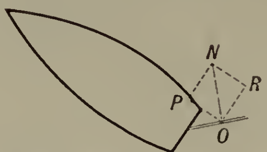
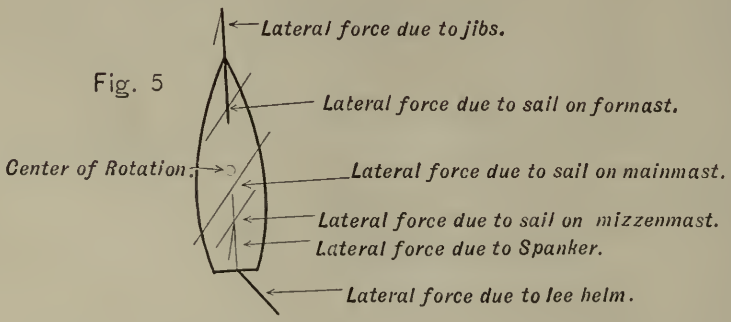


Fig. 4

4 *P O = Longitudinal component of N O, retarding ship.*
R O = Lateral component of N O,, tending to force ship to leeward, and producing a turning moment about the center of rotation.

Fig. 5


Lateral force due to jibs.
Lateral force due to sail on formast.
Center of Rotation
Lateral force due to sail on mainmast.
Lateral force due to sail on mizzenmast.
Lateral force due to Spanker.
Lateral force due to lee helm.

"THE FORCES INVOLVED IN THE STEERING OF A SHIP UNDER SAIL ON THE WIND."

convenient to stop the bight of one of the buntlines to the head-earing cringle of the side opposite that on which the sail will be lowered, and to run this up to the masthead as the earing is eased away. The top bowline of the side on which the sail is to go down is hitched around the bunt for keeping it clear of the top.

A course is unbent exactly like a topsail except that no precautions are needed for keeping it clear.

To UNBEND SAIL.—Man-of-war routine. Call,

Unbend sail!
Stand by to lay aloft sail-loosers!
Aloft sail-loosers!
Lay out and unbend!

The sails and gear are unbent, buntlines passed around the sail for lowering, the earings cast adrift but not let go, and other preparations made as already described.

When all are reported ready,

Stand by! Ease away! Lower away!
Lay in! Lay down from aloft!

CHAPTER XXVI.

MANŒUVRING UNDER SAIL.

§ I PRELIMINARY.

The forces acting upon a ship manœuvring under sail are theoretically numerous and complicated; but so far as they are of practical importance in the handling of a ship they may be reduced to very simple terms. It will be convenient to consider them as they are manifested in the case of a ship sailing close-hauled and manœuvring to pass from one tack to the other.

It is sufficiently accurate for our present purpose to regard the sails as flat surfaces making an angle with the keel as in Fig. I, Plate **133**. The ship being close-hauled, the wind is from forward of the beam and impinges upon the sail at a small angle.

It must be observed that the wind with which we have to deal is the apparent, and not the true, wind. The motion of the ship modifies the direction and force of the wind as felt by the sails; and it is this modified, or "apparent" wind, of which we have to consider the effects.

In Fig. I, B C represents the direction and force of the wind impinging upon a sail. It is clear that E C, the component of this force paralleled to the surface of the sail, can exert no effect. The other component, D C, acts at right angles to the surface and is effective, but not altogether in producing headway; for it, in turn, may be separated into components; one, longitudinal, driving the ship along the line of the keel; the other, lateral, producing leeway (Fig. 2). Evidently, if the lateral component, G C, is applied on one side of the axis of rotation of the ship, it will produce a "turning moment" and will become of importance in the manœuvring of the ship.

Still other forces are introduced if the helm is put over to one side, throwing the rudder diagonally across the keel line. Here the resistance of the water against the face of the rudder, M O, may be resolved into two components; M N, parallel to the surface of the rudder and therefore ineffective; and N O, perpendicular to the surface. N O, again, may be resolved into a component parallel to the keel (retarding the ship) and another perpendicular to the keel, producing leeway and giving rise to a turning moment about the axis of rotation. Both the longitudinal and lateral forces above referred to are opposed by the resistance of the water. For the present, we are principally concerned with the lateral forces, in connection with their tendency to turn the ship. The lateral force of the wind may be regarded as concentrated at one point, which we will call the "center of lateral effort"; and the corresponding resistance of the water, as concentrated at a similar point, the "center of lateral resistance." If these two points coincide, the ship will hold a steady course; otherwise she will tend to turn. If the center of effort is forward of the center of resistance, the head will turn to leeward; if the opposite conditions obtain, the stern will tend to leeward and the head to windward. We have, in the rudder, a means of quickly shifting the preponderance of force to either side, and so of counteracting or of reinforcing the turning tendencies due to the sails.

If a ship is deeper aft than forward, the center of lateral resistance will be farther aft than under ordinary circumstances; and, *other things being equal,* the head will tend to leeward and lee helm will be required to hold her up. Similarly, if the ship trims by the head, the stern will tend to leeward. In practice, of course, other things are not equal; and marked peculiarities of trim are met by corresponding peculiarities in sail plan; the arrangements being usually such that the ship when sailing close-hauled shall carry a very little weather helm.

In this connection, attention may be called to a force which enters as an important factor into the steering of a ship in a fresh breeze. As the ship heels, the fuller lines of her lee bow above the water line become immersed, and the pressure of the water is increased, producing a tendency for the bow to fly up into the wind, and calling for decided weather helm. In a squall, this tendency to windward may be a serious matter if it is desired to run off. In this point lies the explanation of the fact that weather helm is often relieved by taking in the fore topgallant sail, which, but for its effect in burying the bow, would force the head to leeward.

With regard to the axis of rotation about which the ship will turn, we may, for our present purpose, assume that this passes through the center of gravity. It will be understood from what has been said about the relation of the center of effort to the center of resistance, that this assumption leaves out of consideration many facts of theoretical importance; but it is found to be sufficiently exact for practical purposes, and is usually adopted in calculations upon the turning of ships.

The lateral forces due to the sails and the rudder are shown in Fig. 4, which indicates clearly the turning tendency of each. If we suppose the forces acting to leeward *abaft* the center of gravity, to become suddenly predominant—as by the putting down of the helm, for example—we shall find that the resulting motion of rotation is accompanied by at least two other motions. To begin with, the same force which, applied abaft the center of gravity, *turns* the ship, gives to it at the same time a motion of translation directly to leeward. It is clear that this cannot be otherwise. If an object lying on a smooth table is struck, say half way between the middle and one end, it will rotate, of course, but it will also move bodily sidewise. So with the ship in the case we are considering. It will rotate, but at the same time it will go bodily to leeward. It may happen that the motion of rotation will throw the bow up, more than the motion of translation throws it off; so that the bow may not at any time actually go to leeward of the original line; but the center of gravity will always go decidedly to leeward.

The other factor which comes in to determine the path of the ship when her helm is put down, is the momentum along the original course.

It is clear that the effect of any sail may be varied (in amount) by the way it is set and trimmed. Thus we may reduce the turning effect of the spanker or jib by easing off the sheet, and that of a square sail by bracing in. Similarly, we increase the turning effect by flattening in the sheets or bracing up the yards. The turning effect of a square sail may be entirely destroyed, either by bracing it square or by pointing it to the wind. This is important in many of the manœuvres which we shall have to analyze later.

It should be noted that in many of the instances in which the yards are squared, there is an important gain of manœuvring power in the headway or sternway which is given to the ship. In box-hauling, for example, the ship is thrown up into the wind and everything braced aback with the idea of deadening her headway as quickly as possible and then backing her around stern to wind; but whereas the head yards are immediately braced sharp abox, in order that they shall not only assist in checking the ship and giving sternboard, but shall also pay her head off to leeward, the after yards are merely squared. They thus assist in checking the ship and sending her astern, without opposing the turning of the stern to windward. Later in the manœuvre, when the wind begins to draw abaft the beam, they are kept pointed to the wind and still present no opposition to the turning.

It is important in all manœuvres to remember that when the ship has sternboard the rudder throws the head toward the side to which the *helm* is put.

It is important to remember, also, that the helm is, upon the whole, the most important of the turning powers concerned in the manœuvring; and that its action depends upon the speed of the ship. For this reason, there is often an advantage in holding on to a sail whose direct turning effect is unfavorable to the manœuvre to be executed, as long as it will add to the speed. Thus the turning effect of the foresail is distinctly unfavorable in tacking, but the sail being one of the largest and best pulling sails in the ship, its contribution to the speed may more than offset its unfavorable turning effect, and a dull ship may sometimes be made to tack by keeping fast the foresheet for a while instead of letting it go at the order "Helm's a-lee!"

§ II. TACKING, WEARING, BOXHAULING.

The three principal manœuvres by which a ship may pass from one tack to the other are **tacking, wearing** and **boxhauling.** In tacking, the helm is put down, the ship luffs into the wind gradually, holding her headway as long as possible, and, having brought the wind ahead, falls off, bringing it onto the side opposite that where it was originally. In wearing, the helm is put up and the ship sails around, her head going to leeward and the sails remaining full; and having brought the wind aft, is hauled up on the new tack. In boxhauling, she is thrown up into the wind and the yards are braced aback at once, with a view to stopping her as quickly as possible. She is then backed around, throwing her stern up toward the wind; and as the sails fill and give her headway, she sails around and is brought to the wind on the new tack, exactly as in wearing.

Since in going from one tack to the other it is usually desired to gain as much ground to windward as possible, tacking is the most advantageous of the above manœuvres; but it requires a fair amount of headway in the beginning, and so is not practicable in very light or very heavy weather. In heavy weather, moreover, it is dangerous to throw the sails aback; and in a short ship under sail in a gale, it might be fatal to gather sternboard.

Wearing is usually resorted to when for any reason it is impossible or inadvisable to tack. It involves a considerable loss of ground to leeward.

Boxhauling stops the way of a ship very quickly, and brings her around on the other tack without covering any great amount of space either to windward or to leeward. It would be resorted to if danger were suddenly discovered ahead, to windward, and on the lee bow.

Boxhauling frequently takes the place of tacking when the attempt to tack fails. If the ship, after being brought up nearly head to wind, refuses to come about, she may be boxed off and backed around exactly as in boxhauling. See "Missing Stays."

TACKING. (Fig. 1, Plate **134.**)

It is important, in tacking, to begin with good headway and to hold this as long as possible. A smart ship, properly handled, will tack without gathering sternboard; and this is what is always aimed at. It is for this reason that the helm is *eased* down, the spanker boom hauled amidships *gradually*, and the fore sheet kept fast as long as the sail will draw. If at any part of the manœuvre the ship is found to have lost headway, the helm must be righted; and if she gathers sternboard, it must be shifted.

The orders for tacking are as follows:

Ready About! Stations for Stays!

> Man the spanker sheet, fore and main clew-garnets, lee main top-bowline, weather main sheet and lee main tack, weather main and lee cross-jack braces. Tend the jib sheet, fore and main tacks and sheets, lifts, braces, and bowlines.

The greater part of the force should be on the weather main and lee cross-jack braces; and hands from the other gear go to these when no longer needed elsewhere. If the after yards are swung, as they should be, while the wind is a little on the original weather bow, the yards will fly around violently until past the square mark and then start to swing back. A few hands should be ready to run away with the slack of the braces as the yards swing, while the others stand by to clap on when they stop, and brace them up smartly.

Plate No. 134.

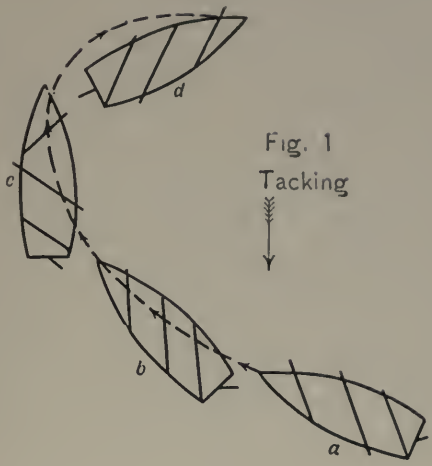


Fig. 1
Tacking

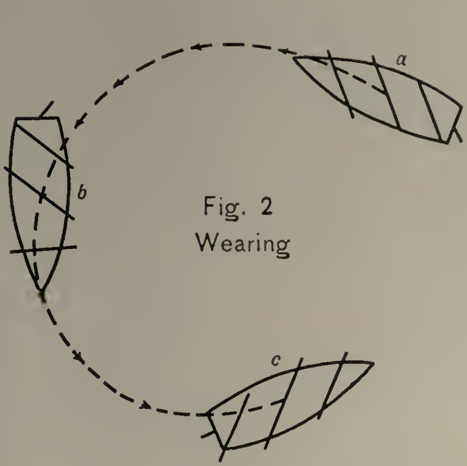


Fig. 2
Wearing

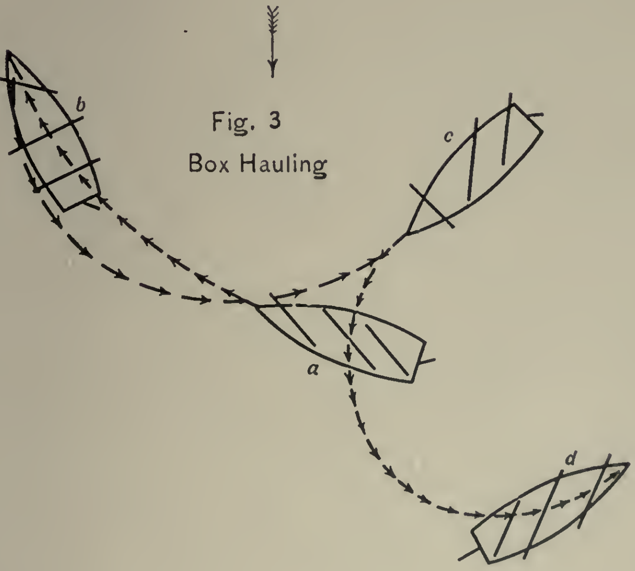


Fig. 3
Box Hauling

MANOEUVRING UNDER SAIL.

When the men are at their stations,

Ready! Ready! Ease Down the helm! Haul the spanker boom amidships!

When the jib lifts, the helm being down,

Helm's a-lee!

The fore and jib sheets are let go. With a dull ship, the fore sheet may be held on until the next order.

When the wind is out of the lee clew of the mainsail,

Rise tacks and sheets! Let go and overhaul the weather lifts!

The clews of the courses are raised sufficiently to clear the rail, the lee main tack and weather main sheet are shortened in. If the ship is a dull one and there is doubt about her coming around, the fore tack should be kept fast.

Just before the wind comes ahead, while it is from a quarter to half a point on the bow, or with a smart ship even more than this,

Haul taut, Mainsail haul!

The after yards are swung and braced up sharp on the new tack, the main tack boarded and the sheet hauled aft. With a quick-working ship, there will not be time to get things entirely to rights aft, before swinging the head yards; therefore, having done what time permits, get the men on the head braces, and as the after sails begin to lift,

Haul well taut, Let go and haul!

The head yards are swung and braced sharp up.

The ship must be watched to see that she does not fall off too far and the helm must be righted at the proper time. If she is inclined to fall off,

Avast bracing! flow the head sheets! Put the helm down!

As she comes to,

Brace up! Gather aft!

Meet her with the helm and head sails and trim the head yards. Get all the yards sharp up, tacks down, weather lifts and braces taut; haul the bowlines and lay up all the gear.

Get the main tack down before the final bracing of the yard, leaving the lee brace, sheet, and weather lift, slack. Having got the tack well down, brace the yard sharp up, get the sheet aft, haul taut the weather lift and brace. As the lee brace has a downward pull, it would, if taut, prevent getting the tack down properly.

WEARING. (Fig. 2, Plate 134.)

Here it is important to get around in the shortest possible space; and although a certain amount of headway is necessary (and indeed unavoidable), the sails are worked for their full turning effect rather than for headway.

The orders are as follows:

Stations for Wearing!

Man the main clew-garnets and buntlines! Spanker brails! Weather main and lee cross jack braces!

When all is ready,

Haul taut, Up mainsail! In spanker! Put the helm up!

As she goes off,

Clear away the after bowlines! Brace in the after yards! Let go and overhaul the weather lifts!

Keep the after sails lifting, so that they shall oppose no resistance to turning. When the wind is on the quarter they will be sharp up on the new tack. Then,

Weather head braces! Fore clew-garnets!

When the wind is aft,

Rise fore tack and sheet!

Clear away the head bowlines! Square away the head yards! Shift over the head sheets!

Get the spanker boom well over to the new lee quarter.

Man the main tack and sheet! Spanker outhaul!

As the wind draws a little to the new weather side,

Clear away the rigging! Haul aboard! Clear away the brails! Haul out!

The head sheets are shifted over when before the wind, but not hauled aft.

The after sails are now working with the helm to bring her to the wind on the new tack, and the head yards being square oppose no resistance. As she comes up, man the head braces, and just before she has the wind abeam begin bracing up the head yards. Meet her with the helm and head sails and by bracing up. Steady her by the wind, trim the sails and straighten up things fore and aft.

In a light breeze, the main topsail should be kept full, to give her good steerage way. When it has been braced square, leave it so long enough to square the head yards, then man the main braces again and brace sharp up. The mizzen topsail in this case is braced as before; that is to say, it is kept lifting until it is sharp up.

BOXHAULING. (Fig. 3, Plate **134**.)

When there is not room for tacking or wearing, the helm is put hard down at once, the mainsail and spanker taken in, and the ship brought into the wind with everything aback, as quickly as possible—the head sheets being lighted up and lee head braces checked to let her come up freely and to deaden her headway. The head yards are then braced abox and the after yards squared. She will head-reach somewhat, but considerably less than in tacking; and having come to rest, will gather sternboard and back around, throwing her stern up more or less into the wind. In order that the after sails shall present no resistance to turning in this way, they are kept pointed to the wind (from the time when the wind is brought abeam) until they are sharp up on the new tack. When she has backed around as far as she will (the wind being from two to four points abaft the beam), the head yards are squared, and, as she gathers headway, the helm is shifted. From this point on, the manœuvre is identical with the final part of wearing.

The statement is often made that a ship gains to windward in boxhauling. This is not usually the case. But she loses less to leeward than in wearing.

Under ordinary circumstances, the emergency not being such as to prohibit the use of conventional formalities, the orders are given as follows: (Suppose the ship to be on the starboard tack.)

Ready about! Stations for boxhauling!

Man the main clew-garnets and buntlines! Spanker brails! Fore clew-garnets! Put the helm down! Light up the head sheets and check the lee head braces!

As soon as the gear is manned,

Rise tacks and sheets! Up mainsail! In spanker!

Man the weather head and main and lee cross-jack braces!

Haul taut, Clear away all the bowlines! Square away the after yards! Brace abox the head yards! Haul flat aft the head sheets!

If there is plenty of space to windward, the yards need not be braced until she has lost headway. But in such a case, tacking would usually be preferred to boxhauling.

Having ranged ahead for a distance much shorter than the reach made in tacking, she comes to rest, gathers sternboard, and backs, turning at the same time.

The head yards, head sails, and lee helm, pay her head off, while the after yards, being square, add to the sternboard and so help the helm.

As the wind comes abeam, the after sails lift. If they were allowed to fill now, they would stop the sternboard; so

Man the starboard main and port cross-jack braces!

Brace the after yards gradually up on the new tack, keeping the sails lifting until they are sharp up: the wind being then on the starboard quarter. The ship will probably lose sternboard rather earlier than this, but the head yards and head sails will still turn her a little. It is now necessary to gather headway; so

Man the head braces! Haul taut, Square away!

As the sails fill and she gathers headway,

Shift the helm!

As the wind draws aft, bear the spanker boom over to the lee quarter.

Man the main tack and sheet! Spanker outhaul!

When the wind is a little on the new weather quarter,

Clear away the rigging! Haul aboard! Clear away the brails! Haul out!

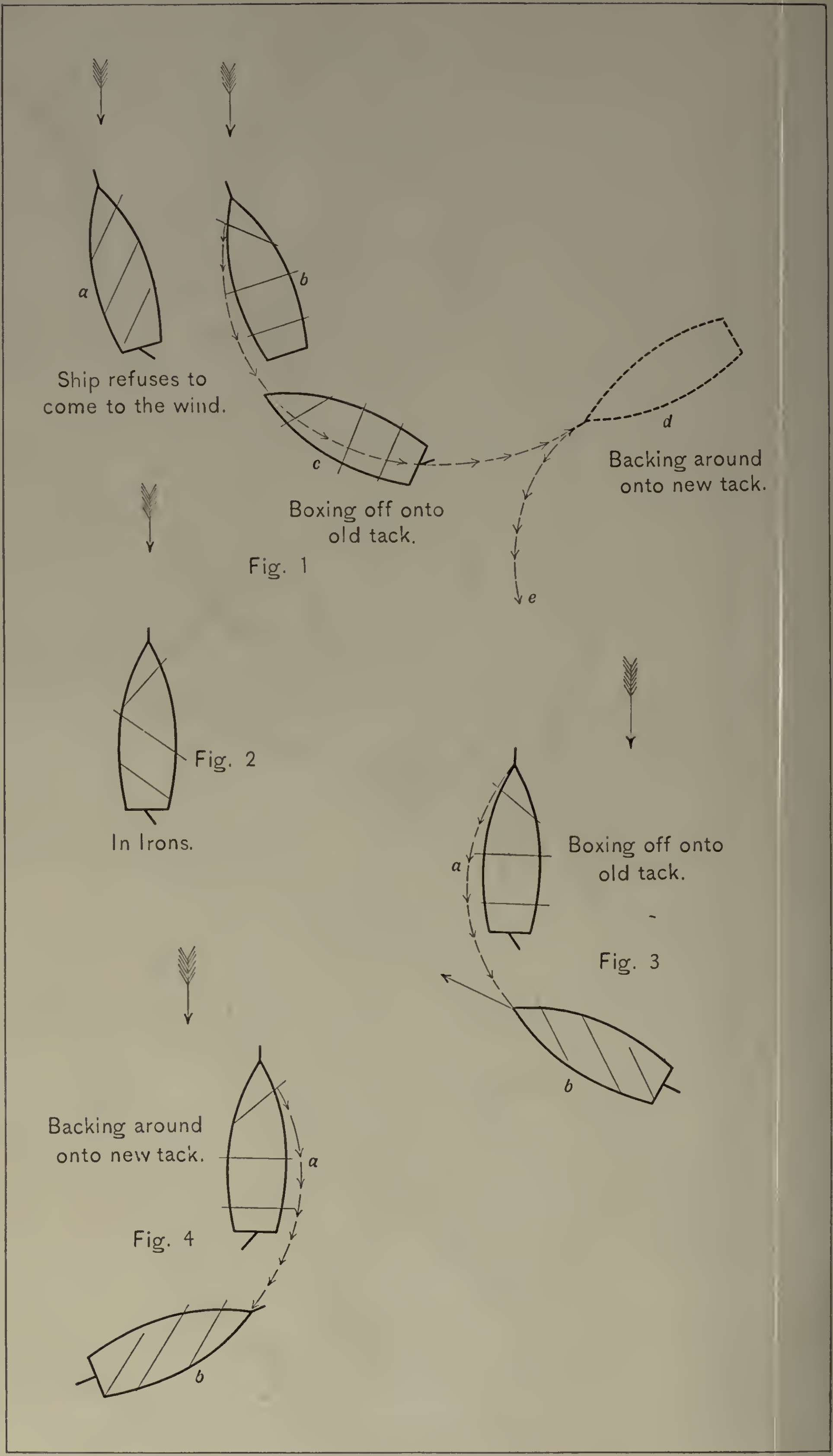
With the after yards sharp up and sails drawing, head yards square, head sheets flowing, and helm a-lee, she comes up, and is met, as in the final part of wearing, by bracing up the head yards, hauling aft the head sheets, and easing the helm.

As already explained, boxhauling is usually an emergency manœuvre. In such a case, all preliminary orders are omitted, the helm is jammed down, bowlines and lee braces thrown off fore and aft, and the yards allowed to swing as far as they will, deadening her headway at once. The gear is manned as quickly as possible; then,

Up mainsail! In spanker! Square the after yards! Brace abox the head yards! Haul flat aft the head sheets!

If there is not space to windward for even the limited reach that would result from this manœuvre, then "hard up" instead of "hard down," man the gear as before, take in the main sail

Plate No. 135.



Ship refuses to come to the wind.

Boxing off onto old tack.

Backing around onto new tack.

Fig. 1

Fig. 2

In Irons.

Boxing off onto old tack.

Fig. 3

Backing around onto new tack.

Fig. 4

MISSING STAYS

and spanker, square the after yards, brace abox the head yards, and haul flat aft the head sheets.

In this case she will probably not gather sternboard, but will "wear" around in a comparatively short space. This manœuvre, although it resembles boxhauling in some respects, is a genuine case of wearing, and is properly known as "Wearing short Around."

§ III. VARIATIONS OF THE PRECEDING MANŒUVRES.

Missing Stays.

It often happens that, in an attempt to tack, a ship having come up until she has the wind nearly ahead refuses to come around, and, after losing headway, gathers sternboard and falls off very slowly toward the old tack. She may be made to fall off more rapidly if the head sheets are flattened in and the spanker sheet eased off; but if this is not sufficient, she must be boxed off.

Suppose she was originally on the starboard tack:

Man the starboard head and main and lee cross-jack braces! Main clew-garnets and buntlines! Spanker brails! Haul taut! Up mainsail! In spanker! Square away the after yards! Brace abox the head yards! Haul flat aft the head sheets!

The helm is still a-lee (port) and as she gathers sternboard she will fall off to port. (Fig. 1, *b*, Plate **135.**)

Observe that up to this point the manœuvre is practically identical with boxhauling. The ship was brought up into the wind, the head yards were braced abox and the after yards squared, and the ship is now going astern and turning to leeward. At this point, then, we may if we choose, continue as in boxhauling and so come around onto the new tack; or we may, when she has fallen off sufficiently, recover her on the old tack and stand on for another trial.

If it is decided to recover her on the old tack, the after yards must be braced up as the wind draws toward the beam (say at *c*), the mainsail and spanker set, and the head yards swung as in tacking.

If it is decided to back around onto the new tack, this is done in all respects as already described in boxhauling. (Fig. 1, *d*, *e*, Plate **135.**)

It may happen that the after yards have been swung before it is recognized that she is not coming around; so that now she lies dead in the water, with the head yards sharp up by the port, and the after yards sharp up by the starboard, braces. In this position she is said to be "in irons" (Fig. 2, Plate **135**). There may still be a slight tendency to fall off onto the old tack, but it will be much less marked than in the case where none of the yards have been swung. With the yards braced like this, the ship is practically unmanageable. She may be brought under control and boxed off as in the case already described, by squaring the after yards and bracing the head yards around (Fig. 3, Plate **135**); or she may, by a little coaxing, be boxed off onto the new tack, not by backing around stern to wind as in boxhauling, but by leaving the head yards as they are (sharp up on the old tack), squaring the after yards and shifting the helm to starboard (Fig. 4, Plate **135**). As she goes astern now, her head goes off to starboard instead of to port, and she gradually brings the wind on the port bow. When the after sails will draw, they are braced up, the head yards are swung, and she is steadied by the wind on the new tack. This is the simple and natural way of proceeding when it will answer, as the variation from tacking is very slight; but in some ships the disposition to go back to the old tack after missing stays is so pronounced that they cannot be cast the other way unless it happens that the wind has come absolutely ahead.

On the other hand, there are many dull ships which are always worked in this way, and are considered to have been tacked when they have been backed around as just described.

Another manœuvre sometimes resorted to after missing stays is shown in Fig. 1, Plate **136**. The after yards having been swung and the ship being in irons, swing the head yards also, keep the helm down, haul flat aft the head sheets, take in the mainsail and spanker, leaving everything flat aback. She will go astern, and, by reason of the lee helm and the excess of pressure under the lee quarter, will turn her stern up into the wind as in boxhauling.

The pressure under the lee quarter here referred to corresponds exactly to the force which has been described in § 1 as acting under the lee bow when the ship is going ahead and heeling. The lines at the bow and quarter are fuller above water than below, and a ship in heeling immerses these fuller lines on the lee side only, and so increases the pressure there.

Plate No. 136.

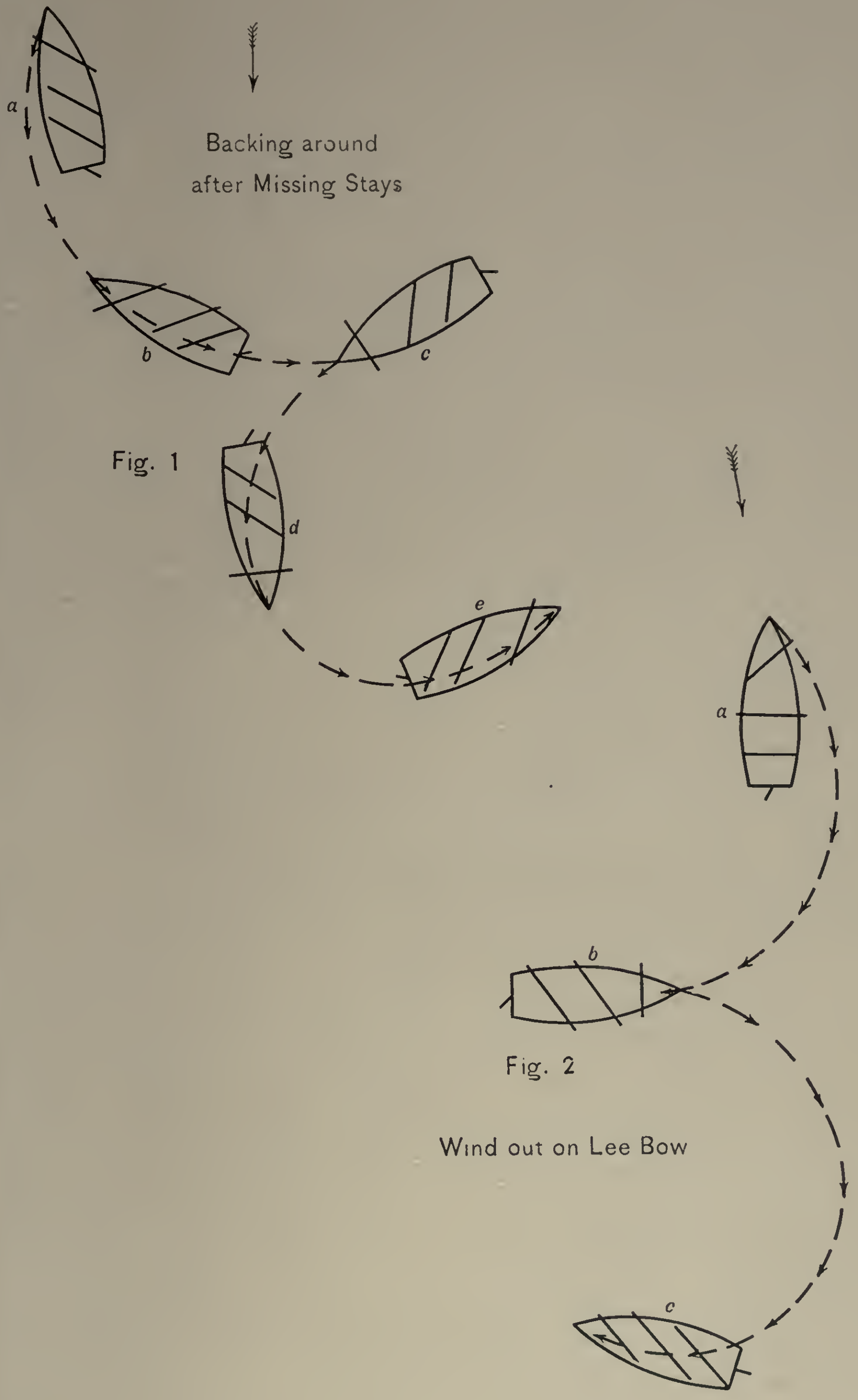


Fig. 1

Fig. 2

MISSING STAYS. WIND OUT ON LEE BOW.

Just how far the ship will turn in this manœuvre depends upon a number of factors which will vary with circumstances, but she will in any event bring the wind well abaft the beam. When she will turn no further, the head yards are squared, and presently give her headway. The helm is then shifted and she is steered around and brought by the wind as in the final part of boxhauling and wearing. This differs from boxhauling only in that, at the beginning of the manœuvre, the after yards are braced sharp up (aback) on the new tack instead of being squared.

If the ship comes to against the helm and throws the sails aback, proceed exactly as if she had gotten into the same position by missing stays before swinging the after yards; that is to say, flatten in the head sheets and put the helm up. If she does not go off, brace abox the head yards. If she still does not go off, up main sail, in spanker, square the after yards to give her sternboard, shift the helm, and so back her off until the sails will draw on the old tack, when brace up the after yards, swing the head yards, and stand on. (Fig. 1*c*, Plate **135**.)

The wind sometimes comes out on the lee bow. In this case the ship may be backed around and brought by the wind on the old tack, as in Fig. 2, Plate **136**. It will be seen that this, again, is much like boxhauling. Suppose she was originally on the starboard tack, and the wind has come out on the lee bow. Leave the head yards as they are, square the after yards (taking in the mainsail and spanker) and put the helm to port.

When she loses headway, right the helm and shift it as she gathers sternboard. She will back around, throwing her stern up to windward.

As the after sails lift, brace them up to keep them lifting, until they are sharp up. Square the head yards. As she gathers headway, shift the helm (to port). When the wind is aft, set the mainsail and spanker and bring her to the wind.

Except in the beginning, this is exactly like boxhauling.

Another way to bring her around onto the old tack after being caught aback is to leave the yards as they are—merely taking in the spanker—and let her gather sternboard and back around, with starboard helm, until the sails fill and give her headway; then shift the helm and let her come up to the wind. This is called "Chapelling Ship" because it involves no manning of gear and may be done without noise.

To Heave To.

When it becomes necessary to deaden the headway of a ship for lowering a boat or for any other purpose, she is "hove-to" by throwing either the fore or the main topsail aback, the course being first taken in. If the ship is on the wind, the main topsail is the one to be backed; if she is sailing free, with the yards square or well braced in, it is better to back the fore topsail.

ON THE WIND, UNDER ALL PLAIN SAIL.

Man the main clew-garnets and buntlines! Weather main braces! Haul taut! Up mainsail!

Brace aback!

The ship is luffed a little, but not enough to catch the fore topsail aback. To keep her under control she must be allowed to forge ahead slowly. She will thus come up and fall off. If she falls off too much and begins to gather headway,

Flow the head sheets! Haul the spanker boom amidships!

If she comes too high,

Flatten in forward! Ease off the spanker sheet!

WITH THE WIND AFT, TO HEAVE TO ON THE STARBOARD TACK.

Hard aport! Man the fore clew-garnets and buntlines! Up foresail!

Port main and starboard cross-jack braces! Overhaul the port lifts! Haul taut! Brace up!

Man the spanker outhaul! Clear away the brails! Haul out!

If the breeze is fresh, take in the royals; or in an emergency let go royal sheets and halliards; as the wind will be much stronger (apparently) when you have rounded to.

If stun'sails are set and there is not time to take them in, let fly tacks and sheets, and haul the sails down when you can.

Man Overboard.

The life-buoy must be dropped (as near the man as possible), the ship hove-to, and a boat lowered.

If on the wind,

Hard down! Let go the life-buoy! Let go the lee main braces and main tack and sheet! Clear away the lee life-boat!

Much time is saved by throwing off the lee main braces and main tack and sheet at once. This may be done (except as to the tack) by the quartermaster or even by the officer of the deck himself.

As quickly as possible, men (previously instructed) are sent aloft to keep the man in sight.

(See remarks in Chapter XXIII on the subject of markers, etc.)

The life-boat is manned and lowered, and pulls back for the man.

There has been much discussion as to whether a ship should merely heave to, for a man overboard, or go about, lowering the boat in stays and leaving the main topsail square. Each plan has advantages and each is advocated by good authority. It may be observed, however, that modern sailing ships do not tack as easily as did those of a quarter century ago, and that many if not most of them would probably refuse to tack with the helm jammed hard down at once.

If running free, the ship is brought to with the fore topsail to the mast as already described. As an extreme case, suppose the wind aft and stun'sails set both sides.

With the wind aft, the officer of the deck should always know which way he is going to put his helm for rounding to, so that he may give the order instinctively.

Hard aport! Let go the life-buoy! Let fly stun'sail tacks and sheets!

Clear away the port life-boat!

Port main and starboard cross-jack braces!

Spanker outhaul!

Brace up! Haul out the spanker!

Fore clew-garnets! Up foresail!

Haul down the stun'sails when an opportunity presents.

BRACING YARDS.

The yards being square, to brace up on the starboard tack.

Man the port head and main and starboard cross-jack braces!

Let go and overhaul the port lower lifts! Clear away the bowlines!

Haul taut! Brace up!

The yards being sharp up on the starboard tack, to brace around and sharp up on the port tack.

Man the weather head and main and lee cross-jack braces!

Fore and main clew-garnets! Let go and overhaul the weather lifts!

Rise tacks and sheets! Clear away the bowlines!

Brace around!

If proposing only to square the yards, the final order is, **Square away!**

The yards being sharp up on the starboard tack, to brace abox the head yards.

Man the weather head braces! Fore clew-garnets! Let go and overhaul the weather fore-lift! Rise fore tack and sheet! Clear away the head bowlines! Brace abox!

The yards being square, to brace them abox; viz., the head yards on one tack, the after yards on the other.

Man the starboard head, port main, and starboard cross-jack braces! Let go and overhaul the lee lifts!
Haul taut! Brace up! Brace abox!

The yards being sharp up on the starboard tack, to square the after yards and brace abox the head yards.

Fore and main clew-garnets and buntlines! Spanker brails!
Haul taut! Up courses! In spanker!
Man the weather head and main and lee cross-jack braces!
Let go and overhaul the weather fore-lift!
Clear away the bowlines!
Square away the after yards!
Brace abox the head yards!

In bracing the yards to meet a shift of wind or a change of course the rule is to brace the head yards first if the wind has veered ahead (bracing up), and the after yards first if it has hauled aft.

If stun'sails are set, it is important to attend carefully the stun'sail gear; manning the halliards, lifts, and burtons, the after guy, boom brace, tacks and outhaul, when bracing in; and easing away on the same gear when bracing up.

IN A GALE.

As the breeze freshens, the light sails are furled and the topsails reefed down. As it becomes clear that a severe gale is in prospect, the light yards are sent down, and, for very bad weather, the topgallant-masts also. If night is coming on it is particularly important to make everything snug before dark.

The remarks of Chapter XX upon running before a sea are as applicable to sailing vessels as to steamers; but it does not follow, with sailing vessels as it does with steamers, that the ship may be stopped and allowed to take up her own position. The excessive rolling that would result from this would be dangerous for a ship with lofty spars. Such a ship, therefore, when she cannot run with safety, should be brought up with wind and sea on the bow and should thus lie-to, under such sail as will best hold her up. This varies with the build and trim of the ship. Many ships do well under a close-reefed main topsail (or lower topsail), storm mizzen or mizzen storm staysail, and fore storm staysail.

A sea anchor (Plate **123**) is very useful with a sailing ship as there is here no screw to hold the stern from swinging off to leeward as in the case of a steamer. All square sail is of course taken in before the sea anchor is put overboard, but the spanker may be set with great advantage.

Oil should be freely used along the weather side in lying-to, and from both bows in riding to a sea anchor; or an oil bag may be attached to the line from the anchor.

(See § II, Chapter XX.)

The hatches are battened down as the gale comes on, life-lines stretched along the deck, and all movable articles lashed.

CHAPTER XXVII.

GETTING UNDERWAY AND COMING TO ANCHOR UNDER SAIL.

§ I. GETTING UNDERWAY.

If the ship is riding to the wind, it is necessary to "cast" her head to one side for filling away, and the general rule is to cast from the anchor. It must be remembered, however, that the ship will gather sternboard as soon as the anchor is tripped; and if there is danger on either side it may be well to cast toward it, as the sternboard will thus be made away from it and by proper use of the helm and sails the ship may be backed off until space admits of filling away and making a reach toward the danger or of wearing around and coming by the wind on the other tack.

It is usual to make sail before tripping the anchor, but there are many circumstances under which this is not advisable. If the wind is fresh, and the ship is riding to it, to make sail would put a heavy strain on the ground-tackle and might start the anchor and drive the ship astern without an opportunity to cast her and fill away. And with the wind abaft the beam and fresh, she would drive up over the anchor, making quite as much trouble in a different way.

There are many circumstances, therefore, under which it is right to weigh first and make sail afterward, or to set the head sails only, and wear around under these when the anchor is aweigh. Under still other circumstances, usually circumstances of emergency, the topsail yards are mast-headed and braced up, and the sails loosed and held up by stops which can be cast off in a moment, allowing the sails to be sheeted home with the least possible delay. In cases of great emergency, where there is no room to go astern, the yards are mast-headed and braced up as just described, the courses loosed as well as the topsails, all gear led out for sheeting home in a hurry, and a line passed forward from the weather quarter to the bow, ready for bending to the cable. Preparations are made for slipping at 15, 30 or 45 fathoms as suggested by circumstances, and the chain hove in until the shackle is at a convenient point for unshackling. When all is ready, bend the line to the cable outside, man the gear and the hawser, slip, put the helm up, run away with the hawser, make sail as she falls off, cut the hawser and stand out.

TO WEIGH AND STAND OUT ON THE WIND, casting to port.

Call:

All hands up Anchor!

Heave in to a short scope—say fifteen fathoms—and stopper the chain. Then,

Make Sail!

As soon as the hands are on deck,

Stand by to lay aloft, loosers of the topgallant sails and royals!

The loosers of the light sails and the captains of tops man the rigging.

Loosers of the topgallant sails and royals in the tops!

Stand by to lay aloft sail-loosers!

Loosers of the topsails and courses man the lower rigging, loosers of the light sails, the topmast rigging,

Aloft Sail-loosers!

The men being ready in the slings of the yards,

Lay out! Loose!

Man the topsail sheets and halliards! Tend the braces!

The sails are loosed and held well up on the yards. When all have reported ready,

Stand by! Let fall! Lay in! Lay down from aloft!

Sheet home and hoist away the topsails!

The yards are hoisted square, the braces being left slack.

The topsails being up,

Man the starboard head, port main and starboard cross-jack braces! Let go and overhaul the lifts!

Haul taut! Brace up! Brace abox!

The head yards are braced up on the port tack, the after yards on the starboard tack. The starboard jib sheet is hauled aft and the jib halliards led along. Then,

Man the bars! Heave around!

As soon as the anchor is aweigh, the helm is put to port, and as she gathers sternboard, this, with the foretopsail, will pay the head off to port.

Man the jib halliards! and as soon as the jib will draw,
Clear away the downhaul! Hoist away the jib!

As she falls off,
Man the port head braces! and as the main topsail begins to lift,
Haul taut! Brace around!

Right the helm as she fills away, haul out the spanker, set the light sails and the courses, haul the bowlines, cat and fish the anchor, and stand out. In a very light breeze, the light sails may be set immediately after the topsails and before starting the anchor.

If there is danger astern, so that no sternboard is permissible (the wind being ahead), a kedge may be carried out and the ship warped ahead as the anchor is lifted, thus gaining the necessary space to admit of casting. To make this still more effective, a line from the quarter may be passed forward ready to bend to the warp outside the forecastle chock. The topsail yards are then mastheaded and braced up (together with the lower yards). on the tack on which the first reach will be made;—say the starboard tack. The topsails and courses are loosed and the gear led along, and the head sails are hoisted. The anchor is then weighed and the ship warped ahead by the line from the kedge. When enough distance has been gained to make it safe, bend on the line from aft, cut away the bow-line, run away with the after line keeping the helm hard a-starboard, and stand by to set the topsails and courses. As she falls off, sheet home the topsails, haul aboard the courses, and meet her by the wind.

If at anchor in a tide-way, allowance must be made for the effect of the current. Advantage may be taken of this to throw the head a little to the side to which it is proposed to cast, before starting the anchor, since the current flowing past the ship will act upon the rudder with the same effect as if the ship were underway and moving through the water. If the ship is tide-rode with the wind on the bow, the natural way to cast will be to leeward and if it is necessary to cast the other way, it will be necessary to use a kedge on the lee bow with a line from the quarter, hauling the stern around by this until the wind is on the bow from which it is proposed to cast.

Under all circumstances when weighing one anchor, have another ready for letting go.

§ II. SHORTENING SAIL AND ANCHORING.

To bring a ship under sail to anchor at a definite spot is a manœuvre that requires the nicest judgment and the greatest care, especially if the anchorage is at all crowded. Every preparation should be made while at a reasonable distance from the anchorage and the light sails and the courses gotten out of the way in good time. It used to be thought a seamanlike manœuvre for a man-of-war to enter the harbor under a press of canvas and to clew up everything at once, letting go an anchor with considerable headway on, if proposing to moor, and laying out the full length of the first cable while ranging ahead. This may be justifiable in certain cases where mooring is a necessity and where there is no other way of laying out the anchors; but in all ordinary cases, the anchorage should be approached with little way on, and the anchor let go, if possible, with sternboard. If standing in on a wind, everything is taken in except topsails, jib and spanker, and the ship headed a little to leeward of her anchorage, her headway being deadened if necessary by checking in the braces. At the proper moment, the recognition of which calls for good judgment, the helm is put down, the jib hauled down, the spanker boom hauled amidships, and the topsails clewed up; the yards being lowered and squared either while clewing up or immediately afterward. If necessary for deadening the headway, the mizzen topsail remains set, being braced square as she comes up to the wind and left so while paying out the chain. In an extreme case, such as a crowded anchorage, all three topsails may be thrown aback (squared) as she comes up. If there is no room for running to leeward and rounding to, she may be headed directly for the anchorage with the topsail braces in hand and the sails kept just lifting, giving her very little headway, and thrown flat aback in time to stop her and give her sternboard at the proper point for letting go.

If coming in before the wind, sail should be shortened even earlier than in the case just described, the light sails and courses being furled when taken in, as otherwise they would add much to the headway. The topsails are hauled up snugly while still at a good distance from the anchorage, but the mizzen topsail sheets may be manned ready for setting the sail aback. If space admits of making a limited sweep,—say to starboard—stand by the starboard anchor, put the helm hard aport, haul out the spanker, and as she comes around and up to the anchorage, let go, and veer away roundly without attempting to snub her until she has plenty of chain. Sheet home the mizzen topsail, bracing it sharp aback.

If circumstances do not admit of even the limited sweep described above, the anchor must be let go and the chain paid out while running; the cable being double-bitted and the headway being checked by hauling to, or, with a modern windlass, by putting on the brake gradually. Experience shows that in this case as in all others where a ship is brought-to on her chain, *the great danger is that of allowing too much headway.*

To Stand in on a Wind and Anchor.

Call, **All hands bring ship to anchor!**

When the hands are at their stations,

Man the fore and main clew-garnets and buntlines! Topgallant and royal clew-lines! Flying-jib downhaul!

Lay aloft and stand by to furl the topgallant sails and royals!

See that the weather topgallant and royal braces are also manned and that the tacks and sheets, halliards and lee braces are tended. Then,

Haul taut! Shorten sail!

The light sails are furled and the flying-jib stowed without further orders.

As the point for rounding-to is approached,

Man the topsail clew-jiggers and buntlines! Jib downhaul!

Stand by the starboard (or port) anchor!

The ship stands on, heading to leeward of her anchorage, her course and speed being regulated as already explained. When it is considered that the proper time has come for rounding-to,

Hard down!

Let go the jib-halliards! Haul down!

Clear away the topsail-sheets! Clew up!

Haul the spanker boom amidships!

The sails having been clewed up,

Man the weather head and main and lee cross-jack braces!

Hands by the lee braces and halliards!

Settle away the topsail halliards! Square away!

All braces and the lower lifts are belayed at the square mark. If it is thought best to keep the mizzen topsail set, it is braced square as the other topsails are taken in.

As soon as the ship begins to gather sternboard,

Stand clear of the starboard chain!

Let go the starboard anchor!

The chain is laid out clear as she goes astern, and hauled-to and secured at the proper scope.

The next order is,

Furl sail!

Stand by to lay aloft topmen! **Aloft topmen!**

Lower yardmen on the sheerpole! **Aloft lower yardmen!**

Lay out and pass in the leeches!

Furl away!

It is important to have the gear intelligently attended on deck; the buntwhips manned and pulled up at the proper time, the buntlines and clew-jiggers lowered when the men aloft are ready for them and not before. If care is given to these points and if the men aloft are watched for signals as to when they are ready, it should be possible to avoid all calling out from aloft.

When all have reported ready aloft (by signal, not by shouting),

Lay in! **Lay down from aloft!**

Remain aloft square-yard men!

The captains of tops and a few other hands remain aloft to straighten things up, and to lend a hand in squaring the light yards. The next order is,

Square yards!

Lifts and braces are manned or slacked as may be necessary, the boatswain or chief boatswain's mate directing. The gear about the deck is laid up neatly and all made snug aloft and on deck. Finally,

Pipe down!

If standing in before the wind, sail is shortened as already described, with such changes as result from the fact that the yards are square and the head sails, main sail, and spanker not set. In rounding-to, the spanker is hauled out, with the boom nearly or quite amidships.

(See Chapter "Making and Taking in Sail.")

A ship standing in with a scant wind may gain to windward by making a series of half-boards; that is to say, by easing down the helm as if to tack, and as the ship reaches up to windward, meeting her and filling away without allowing her to lose headway. This plan is often tried with good effect in yacht and boat sailing.

INDEX.

A.

- Advance of a vessel in turning. 196
- Aground:—
  - A steamer. To get off...... 367
  - Lights for a vessel.......... 229
  - Lights for a vessel, in United States waters..... 244
- Alongside:—
  - A dock. Handling a steamer 282
  - Bringing a steamer......... 287
  - Bringing a steamer, when dock is not clear......... 290
  - To lie, with bow held in. 296, 297
  - To wind a steamer in coming 296
  - Towing 356
- Anchor:—
  - Becoming "shod" 144, 164
  - Clear, to keep a............. 162
  - Dragging 161, 164, 165
  - Fog-signals for vessels at... 232
  - Foul 178
  - Foul, Danger of dragging... 162
  - Letting go a second........ 164
  - Letting go, Ship to be moving 159
  - Lights for a vessel at....... 229
  - Lying at. A good scope of cable required for 160
  - Old-fashioned 143, 144
  - Old-fashioned. Letting go. 157
  - Old-fashioned. To Cat and Fish 154, 155, 175
  - Riding out a Gale at........ 339
  - Single. Riding at.......... 159
  - Should be sighted occasionally 163
  - To be laid out immediately when vessel is stranded... 367
  - To clear from the Ram..... 178
- Anchors:— 143-147
  - Carrying out by Boats... 180-188
  - Old-fashioned and Patent compared 146
  - Patent 144, 145, 146
  - Dunn's 145
  - Hall's 145
  - Martin's 145
  - Smith's 145
  - Tyzack's 145
- Anchors, *cont.*
  - Patent. Handling 145
  - Patent. Letting go from hawse pipe 146
  - Patent. Stockless 144-147
  - Patent. Stowing .. 145, 146, 176
  - Patent. With stock 147
  - The Holding power of...... 143
  - Weights of 186
- Anti-cyclones 307, 308
- Anti-cyclones. Direction of rotation of, explained..... 312

B.

- Backing:—
  - Around into a slip.......... 292
  - Effect of wind upon a Ship.. 201, 215
  - Engines, possible danger of, when stranded 367
  - Of Wind in a Cyclone...... 325
- Backstays. How fitted 28-29
- Bad weather:—
  - Begins with Easterly Wind. 315
  - Clears with Northwesterly Wind 315
- Balance Lug Sails............ 110
- Balsas 96
- Barge 98
- Barometer:—
  - Care of 319
  - Comparison of, with standard 319
  - Correction of 319
- Barometric:—
  - Gradient 308, 309
  - Pressure as determining the direction of the Wind..... 312
  - Tides 320
- Bar. Use of Oil for crossing a 342
- Bearing of the Center of a Hurricane. To determine the 328, 329
- Bearings:—
  - By Pelorus 83
  - Distance of an object by two. 271
  - To determine risk of collision by 234
- Bending:—
  - Cable 150
  - Sail 389

Bending, *cont.*
  Sail, Man-of-war routine.... 391
  To make up a Sail for...389, 390
Belt of Intensified Trade Winds 329
Berthon Boats 96
Bilge-blocks for docking a Ship 303
Bitting a Cable.............. 154
Bitter-end 149
Bitts 154
Blast, prolonged. Definition of. 230
Blocks:—
  and Tackles 60
  How made 60
  Strapping 62
  Strength of 70
  Strength of hooks of........ 70
  Varieties of 61
Boats:—
  Caught in a Gale, in 121
  Carrying, rigged out.....99, 107
  Handling under Oars....... 118
  Hoisting 109
  Speed at which it is safe to lower 366
  To handle, in rescuing the Crew of a wreck..358, 359, 360
  To lower, in bad Weather... 107, 358
  Berthon 96
  Build of 97
  Classification of 98
  Collapsible 96
  Equipment of 101, 102
  Equipment of by English Board of Trade Rules 102
  Handling and Stowing on Shipboard 99
  Handling in a Surf 131-142
  Inspection and Care of..... 101
  Of Men-of-War. Classification of 98
  Of Men-of-War. Rig of, for sailing 109
  Of Merchant Steamers...... 95
  Of Merchant Steamers, how carried 100
  Stowing and handling of.... 99
  Types of, for sailing........ 94
  Use of for running lines in Towing 354
Bobstays. How fitted........ 29
Boilers of Steam-Launches. To clean 129
Boom:—
  For Handling Weights.53, 54, 74
  Forces involved in Handling Weights by a...........53, 54
  Supported by a shore for very heavy weights....... 74
Bottom. Inspection of in dry-dock 305
Bow:—
  and Beam Bearings......... 272
  To get the anchor off the... 175
Bowsprit:—
  Details of 24
  Rigging of 29
Bowsprit-shrouds. How fitted. 30
Braces:—
  How rove 47
  How rove in old-fashioned ships 48
Breeches-buoy. Rescue of shipwrecked crew by means of a 371
Bringing-to the chain......... 154
Brown, Capt. A. H., Views upon lying-to in a Modern steamer 344
Burton, a Spanish............ 66
Burtons, Top- 67
Buoyage:—
  of United States............ 280
  of various countries. Note on the 280
Buoying the stern of a boat for carrying an Anchor... 180
Buoys may be out of place.... 273
Buys-Ballot Law 312

C.

Cable:—
  Advantage of a long scope of 160
  Carrying out, with a Boat.. 180-185
  Length of a 149
  Marking 150
  Nipping the, by the windlass brake 156, 158
  Overhauling 150
  Used with Manila line for towing 355
  Stowing a 149
Canvas:—
  Grades and numbers of..... 41
  Materials for 40
  Requirements for 40
  Weight of 41
Cap. The Lower. To send up 32, 33
Cap, Topmast. To ship the... 34
Capstans:— 152, 153
  Moment of forces in........ 57
  Old-fashioned. To bring the chain to 154
Carvel-building for Boats..... 97
Cat and Ground Chain........ 177
Catting and fishing in one..... 176

- Casks:—
  - Buoying the stern of a boat by 180
  - Floating power of 187
- Center of a Hurricane. To determine the bearing of the 328, 329
- Chain:—
  - Advantage of a long scope of 160
  - Ranging 154
- Chain-Cable 149
- Chain-Cables (see Cables):—
  - Use of, as a Towline........ 346
  - Manufacture of 147, 157
  - Weights of 187
- Channels, Narrow. Rules of the Road for.............. 238
- Charts. Arrangement for using on the bridge......... 267
- Chart-boards, portable 267
- Circles. Turning 195, 196, 197
- Clear Hawse 167
- Clearing Hawse 168
- Clearing weather accompanied by northwesterly wind.... 315
- Clifford's Detaching Apparatus 103, 106
- Clinker-building for Boats.... 97
- Cloud-forms. Description of.. 320
- Cloud-formations in a hurricane 323, 326
- Clouds. Relation of to weather 320
- Cloudiness in cyclonic weather 308, 310
- Coasting in a fog by Soundings 278
- Coasting-Record. Should be kept 272
- Coir 9
- Cold waves. Explanation of. 315, 316
- Collapsible Boats 96
- Collision:—
  - Duty of ships to stand by after 250
  - Effect of speed upon the point where ships will meet 253, 254
  - Facts to be entered in the log 251
  - Laws relating to........... 250
  - Manœuvring to avoid....... 252
  - Manœuvring in a fog to avoid 259-263
  - Risk of, how determined.... 234
  - Rules of the Road for avoiding 234
  - Vessels in, must give information 251
- Command. Lights for a vessel not under 223, 245
- Compasses 81, 82
- Compass. Error in, caused by iron and steel 81
- Compass. Error of should be determined before approaching land 267
- Compass, Log and Lead.....81-93
- Compass-Card 82
- Composition of Forces........ 52
- Compressors 153
- Controllers 153, 154
- Coral reefs. May be made out from aloft 274
- Cross in hawse, cannot be cleared 170
- Crossing, Steamers 237, 253
- Crossing Steamers in United States waters 245, 248
- Crossing ahead. Vessel giving way must avoid if possible. 237
- Cross-trees 26, 33
- Currents:—
  - Danger of, in piloting....... 274
  - Effect of, greater at low speeds 277
  - Effect of in handling a steamer alongside a Dock. 286, 293
  - Tidal. Change of direction from hour to hour........ 276
  - Tidal. Do not coincide with rising and falling tide..274, 275
- Curves of steamers turning... 195, 196, 197
- Cutters 98
- Cyclones. Explanation of.... 307, 308, 312
  - Weather in 308, 310
  - Direction of rotation explained 312
  - Motion of 324

D.

- Danger angles, vertical and horizontal 268
- Dangerous and manageable semi-circles of a cyclone.. 326
- Davits for boats.............. 100
- Depth-recorder, for Sounding-Machine 89, 90
- Deep-sea Lead 88
- Derricks:—
  - Handling weights by..54, 55, 86
  - To calculate strains on....54, 55
- Detaching apparatus for Boats. 103
- Detonating Signal may be used to attract attention....230, 237
- Dew-point 310
- Diagonal-building 97

Differential Purchase 68
Dinghys 98
Dip of horizon 269
Dip-rope 168
Dipping-Lug 110
Disabled vessel. To take in tow 351
Discharge-Current of screw. 190-214
Diseases of Steam Launch Machinery 124, 125
Distance:—
  at which objects can be seen at sea 270
  at which sounds can be heard 231
  of an object determined by vertical angle 268
  of an object in the horizon.. 269
  of an object by two bearings 271, 272
Distress-Signals 240, 249
Dock:—
  Dry-. Arrangement of, for receiving a ship..302, 303, 304
  Dry-. Placing a vessel in... 294, 302, 303, 304
  Getting clear of a.......... 297
  Handling a steamer alongside a 282-301
  To wind a steamer at a..... 294, 295, 296
Docking:—
  a Steamer 286-301
  a large Ocean liner......298-301
Docking-Plan. For placing a ship in dry-dock.......... 302
Doldrums, The 311
Dory 96
Doxrud, Capt. H., Experiences in rescuing the crews of wrecks 362
  Views upon lying-to in a modern steamer 343
Drag of the propeller. Effect of in lying-to............ 334
Dragging anchor 164, 165
Drag-net fishing. Description of 327
Drains. Main and Secondary. 5, 6
Dredgers. Lights for. 227, 228, 243
Drift-lead. Use of 164, 165
Drift-net fishing. Description of 227
Drift of vessels lying with engines stopped in a seaway 352
Dry-dock:—
  Examination of a ship in... 305
  Placing a ship in........294, 302
  Flooding a 306
Duplex Purchase 68

E.

East River. Tidal-currents in. 275, 276
Echoes. Use of, in a fog..... 278
Elbow in the hawse.......... 167
English Channel. Tidal-currents in 275
English Navy. Rig for sailing boats in 111
Equatorial calm-belt 311

F.

Fair tide:—
  Danger of, in coming alongside 286, 289
  Danger of working into a slip. 293
Feed-water for Steam Launch boiler 125
Ferry-boats. Lights for, in United States waters..... 242
Firemain 6
Fishing vessels:—
  Lights for 226, 243
  Right-of-way of 238
Flare-up Light:—
  Used by Fishing vessels.... 228
  Used by overtaken vessels.. 228
  Used by Pilot vessels....... 226
  Used by any vessel to attract attention 229
Float. Use of, for running lines in Towing........... 354
Floating power of Casks..... 187
Flooding a dry-dock.......... 306
Fog:—
  Coasting in a 273
  Does not extend to a great height 266
  It may be possible to see over or under............ 266
  Manœuvring in a, to avoid collision 259-263
  Moderate speed in a. Reasons for 264
  Navigating in a........... 276
  Thin near surface of water.. 266
  To pick up a man overboard, in a 367
Fog-signal. A vessel hearing must stop engines 234
Fog-signals:—
  for steamers 231
  for vessels at anchor.......232
  for vessels unable to manœuvre 232
  for vessels towing and towed 232
  Interval between 231
  Note as to audibility of..... 231
  Unreliability of 277

- Forces. The composition and resolution of 52, 53
- Foresail. To set and take in a 377, 378
- Foul:—
  - Anchor 178
  - Hawse 167
- French Lug 110
- Friction:—
  - in blocks of tackles....60, 63, 64
  - of a tackle. Rule for calculating the 64

G.

- Gaff-topsail. To set a........ 383
- Gale:—
  - Handling a Steamer in a.332, 334
  - Lying-to in a, Under sail... 407
  - Manœuvring in a........... 328
  - Riding out a, at anchor..... 339
- Galvanizing wire-rope 13
- Gear, Running 46-51
- Green light on starboard bow. Danger of a 236
- Groombridge, Capt. J. G. Views of, upon lying-to in a modern steamer........ 344
- Ground-chain 177, 178
- Ground-log 86
  - Gun-tackle 66
  - Gybing a sail............115, 118

H.

- Handling:—
  - a Steamer alongside a dock. 282
  - boats under sail............ 113
  - Heavy weights 54, 55, 72
  - Steamers in heavy weather. 334
  - weights. Practical examples. 76
- Hawse:—
  - Clear and foul.............. 167
  - Open 167
  - To clear 168
  - To clear, by swinging....... 167
  - To clear, in ship with ram-bow 169
- Hawsers. Weights of........ 187
- Heavy weights. Handling.... 72
- Heaving-to for observing the bearing of a hurricane.330, 331
- Heel of a ship in Turning..... 217
- Hell Gate. Rules for steamers approaching 247
- Helm. Use of in handling a Steamer alongside a Dock. 284
- Hemp 9, 10
- High and Low barometric areas 307, 316
- Hoisting a boat in a seaway.. 109
- Holmes' light for boats....... 102
- Hooks:—
  - Automatic Releasing 105
  - and Shackles for Tackles.... 70
  - of blocks, weakness of...... 70
  - Strength of 70
- Horizon, distance of an object in the 269
- Horizontal danger-angle 268
- Horse Latitudes 313
- Housing a Topmast.......... 37
- Hull and fittings of a ship..... 1
- Hurricane. Indications of the approach of a............ 327
- Hurricanes. Origin of 322
- Hydraulic Steering Gear...... 4
- Hydrographic Office. United States Naval. Researches on Use of Oil............ 340

I.

- Indications of the approach of a Hurricane 327
- Inland:—
  - Navigation. Rules for in United States waters 239
  - Rules of countries other than United States 250
  - Waters of United States defined 240
- Inertia:—
  - Moment of 218
  - of Tow. To overcome..351, 355
- International Rules of the Road 220
- Intensified Trade Winds...... 329
- Iron. Danger of bringing near compass 81
- Isobars 307, 309

J.

- Jib:—
  - -boom, and rigging......... 30
  - To bend a.................. 390
  - To set and take in a........ 382

K.

- Keel-blocks of a dry-dock.... 303
- Keel. Construction of the.... 2
- Kick:—
  - of a vessel in turning....... 196
  - of a Torpedo boat.......... 217
- Knots:—
  - for joining two ropes....... 16
  - in a single rope............ 15
  - worked with the strands of a rope.................. 16
- Knotting and Splicing........15-21

L.

Lake Champlain. Battle of.163, 164
Land and Sea breezes........ 317
Landing. To wind a Steamer in making a.............. 296
Latteen-rig for Boats......... 112
Launch fitted with a trunk for carrying out an anchor... 181
Launches 98
Law of Port helm........... 256
Laws relating to the Rules of the Road 250
Lead. Use of the........... 87
Lead-lines:—
  marking 87
  Materials for 88
  must be marked when wet.. 88
  verified before entering or leaving port 267
Letting go an Anchor.146, 157, 158
Lever. The principles of the. 57
Life-car. Rescue of a shipwrecked crew by means of. 371
Life-rafts 96
Life-buoys:—
  Types of 364, 365
  usually too small........... 364
  U. S. Navy type........... 365
Life-saving Service. Instructions of, in case of Shipwreck 370
Light-house. Fixing position by, when in the horizon.. 269
Light-ships may be out of place 273
Lights prescribed by Rules of the Road 221-230
Lights prescribed in Inland Waters of United States.. 241-244
Light, Holmes'. Use of in case of a man overboard.. 365
Light, for a Life-buoy. Importance of as a Marker.. 365
Limited space. To turn in a.. 207
Lines. Running, with a Boat.
Lines. Running, for taking a vessel in tow.. ....353, 354
Log:— 83-87
  Heaving the 84
  Old-fashioned 83
Log-line. How marked...... 84
Logs, patent:—
  Care of 85
  Length of Line for.......... 86
  To determine error of.....85, 86
Lower rigging:—
  To send up................ 31
  To set up................27, 32
Lower Stays. How fitted..... 27
Lower Yard. To send up..... 35
Lower Yard. To send down. 36
Lowermast head. Rigging for 25, 26
"Lows," Barometric 307
Lowering:—
  a boat in bad weather...107, 358
  and hoisting a boat. Use of oil in 342
Lug-rigs for boats........... 110
Lying-to:—
  in a hurricane. Rules for... 330, 331
  in a hurricane. Rules for a Steamer 332, 334
  in Modern Steamers. Opinions of Shipmasters upon. 342
  under sail 407
  with engines stopped....334, 335
  with sea on the bow.....334, 338
  with sea aft, or on the quarter 335

M.

Machinery of Steam Launches:—
  Diseases of 124, 125
  Testing 124, 125
Magazines. Flooding 7
Making and Taking in Sail... 375
Making up a sail for Bending 389, 390
Man overboard:—
  Danger to, from screw...... 364
  from a sailing vessel........ 405
  from a Steamer............ 364
Manageable and Dangerous semi-circles of a Cyclone.. 326
Manifolds. The use of, in Drainage System 6
Manila 9, 10
Manila. Advantages and disadvantages for Towing...... 347
Manœuvring:—
  in a Fog to avoid Collision 259-263
  in a Hurricane 328
  to avoid Collision 252
Markers. Importance of in case of a man overboard.. 365
Marking cables 150
Marks and deeps of a lead-line 87
Marline 10, 11
Masts:—
  Details of 22, 23
  Military 23
Mechanical Appliances on Shipboard 52
Meeting another vessel in a narrow channel 253

Meeting. Steamers. Rules for, in Inland Waters of United States 245
Megaphone. Use of in a fog. 266
Messenger-line, between ships towing 355
Mills, A. R., Capt. S. S. Westernland. Views upon lying-to in a Modern Steamer.. 343
Moderate speed in a Fog:—
  as a matter of Law......... 233
  Definition of 232
  Reasonableness of 264
Moisture, in the Atmosphere.. 310
Monsoons 311, 317
Mooring 150
Mooring. Advantages and disadvantages of 160
Mooring Swivel:— 170
  Advantages and disadvantages of 170
  To put on the.............. 172
  To take off the............. 173

N.

Navigating in a Fog.......... 276
Nautical Magazine. Discussion in, upon Lying-to in a Modern Steamer 345
New Bedford Whale Boat...94, 95
Neilsen, Otto, Capt. S. S. Pennland. Views upon lying-to in a Modern Steamer..... 343

O.

Oars:—
  for pulling and steering a surf-boat 140
  Handling a boat under..... 118, 120, 121
Oil:—
  For Calming Sea........... 340
  Not to be used in cylinders of steam-launches 126
  Use of with a Life-buoy.... 365
  Use of in rescuing the crew of a wreck............358, 359
Oil slick:—
  Cannot be formed to leeward of vessel drifting.......... 342
  Value of as a marker in case of a man overboard....... 365
Open hawse 167
Overboard, Man 364, 365, 405
Overhauling Cables 150, 151
Overtaken vessel 229
Overtaking vessel 238

P.

Parallelogram of Forces 53, 54
Parbuckling 74
Patent logs 85
Path of a hurricane. To plot the 329
Pelorus 82
Pelorus. Adjustment of the.. 82
Pendant. Clear-hawse 168
Pendant-tackle 67
Period of a ship in rolling.... 337
Pilot-charts 332
Pilot-vessels. Lights for..... 226
Pilot-vessels. Steam. Lights for 226, 243
Piloting 267-281
Pivoting point of a steamer turning 195, 196
Position fixed by a single object 269
Port helm. Law of........... 256
Power:—
  Gain in, purchased by a sacrifice of speed 59
  of a Tackle...............62, 63
  wasted by use of an extra sheave 64
Precipitation:—
  Causes of 316
  in a cyclone 308, 310
Propeller. Drag of the, in lying-to 334
Pressure. Normal, throughout the world........... 320
Pumping various compartments of a ship 6
Purchase:—
  Differential and Duplex..... 68
  Special, for heavy work..... 67
Purchases. Different forms of 66

R.

Rainfall of cyclonic weather.. 308, 310
Ram. To clear the anchor from the 178
Range:—
  The use of a, in Piloting.. 272, 273
  The use of a, for determining compass error........ 272
Range-lights. Use of.....222, 241
Ranging chain 154
Recurving of hurricanes. Latitude of 326
Reef-bands 43, 44
Reef-earings 44
Reef-earing. To pass a....... 385
Reef-points 44
Reefing:—
  in a boat.................. 115
  Topsails 383, 384
Reefs. To shake out......... 385

Relieving tackles 68
Rescuing the crew of a wreck. 358
Resolution of Forces......... 52
Revolutions of Screw for measuring speed 86
Richardson, D., Capt. S. S. Noranmore. Views upon lying-to in a Modern Steamer 343
Rig of ships' boats for sailing.. 109
Rigging:—
  Lower. To send up........ 31
  Setting up 32
  Standing 24, 25
  Running 46-51
Rigging ship 31
Right-of-way. Rules for vessels having the........237, 262
Rocket. Ordinary, for throwing lines 354
Rocket-Gun 354
Robinson's Detaching Gear... 103
Rolling:—
  of a ship, dependent upon her period in relation to waves 337
  reduced by change of speed or course 337
  when lying-to with engines stopped 335
Rope:—
  contracts when wet......... 11
  deterioration of, from dampness 11
  deterioration with use 12
  Hemp 9, 10
  Manila 9, 10
  materials of 9
  securing to spars and posts.. 16
  strength of 14
  the manufacture of.......... 9
  Wire- 12
Ropes. Practical rule for strength of 69
Royals. To set and take in... 381
Rules:—
  for handing Boats in a surf. 131-142
  for manœuvring in a hurricane 328, 330, 331
  of the Road............... 220
  of the Road for steamers crossing 237
  of the Road for steamers meeting 236
  of the Road. Inland........ 240
  of the Road. Laws relating to the 250
  for ropes, tackles, etc....... 69
Runner, A 66
Running:
  before a sea in a steamer.335, 336
  before the wind in a boat.115, 116
  at high speed in a seaway. Danger of 335, 336
  lines in taking a vessel in tow 353, 354
  slowly before sea........... 335
Running Rigging 46-51

S.

Sail:—
  Making and Taking in...... 375
  To bend. Man-of-war routine 391
  To make 410
  To unbend 392
Sails:—
  Fittings of 43
  Materials of 40
  Storm- 44, 45
  Studding- 45
  Bending 389
Sail-making 42
Sailing:—
  Boats 113
  Rig of Ship's boats for..... 109
Sailing vessels. Lights for... 224
  Rules of the Road for...234, 235
  Fog signals for 232
Salt water in Steam Launch boiler 127
"Saratoga," The, at Lake Champlain 163, 164
Screw-Currents. The nature of 190
  The effect of upon steering 190-214
  The effect of in handling a steamer around a dock.285, 288
Sea-anchor:—
  for a boat 102, 121
  used with advantage from stern 339
  Uselessness of with a long steamer 338
  valuable for short ships and sailing ships 338
Secondary Drain 6
Seizing-stuff 10, 11
Semi-circles of a Cyclone. Dangerous and Manageable 326
Setting up Rigging........... 32
Sextant angles. Use of in piloting 268
Shackle-pins 148
Shackles:—
  Preferred to hooks for heavy weights 70, 76

Shackles, *cont.*
  Slipping on wild-cat........ 174
  Strength of 70
Shallow water. Effect of upon steering 216
Sheave. Disadvantage of a small 63
Sheathed ships 2
Sheers. Rigging 74, 75
Ships. Types of.............. 1
Shipmasters Society, London. Discussion upon lying-to in a modern steamer...... 344
Shipwreck. Instructions in case of 370
Shores for keeping vessels upright in dry-dock......... 304
Shrouds 24-30
Side-lights 221
  How screened 221
  Note on 221
Signals:—
  for vessels towing.......... 353
  for use in Rescuing the Crew of a Wreck 360, 361
  for use in case of Shipwreck 373
  in a Fog 230, 231
  of distress 240, 249
Size of rope for a given load. To calculate the 69
Slack water. Does not coincide with high and low.274, 275
Slessar, Capt. S. S. Pechili. Views upon lying-to in a modern steamer 344
Sliding-gunter rig for boats... 110
Slip. Working into a......291-294
Slip-stoppers 153
Slowing engines when running before a sea. Effect of.... 336
Small-stuff 10, 11
Small vessels. Lights for.... 225
Smooth water. Towing in.... 350
Sound signals:—
  for fog 230, 244, 245
  for vessels in sight of each other 239, 249
  Note as to audibility of..... 231
Sounding in deep water....... 88
Sounding Machine:— 88-93
  Importance of, in a Fog.... 277
  Method of using, in a Fog.. 277
  Use of, in Fixing position.. 274
Space in which a steamer can be stopped 265
Span:—
  for towing. Details of fitting 348
  Use of for handling weights. 56, 57, 73
  Tension on a............... 57
Span, *cont.*
  Riding to a, when moored.57, 166
  Weakness of a 59
Spanker. To set and take in. 382
Spanish-Burtons 66, 67
Spars 22
Speed:—
  Danger of, in approaching a dock 287
  effect upon turning circle... 197
  in a Fog 233, 263, 265, 276
  Legal definition of "Moderate" 233
  Loss of, for gain in power.. 64
  Measuring by revolutions of the screw 86
  of a ship in turning......... 197
  Slow. Advantage of in a seaway 336, 337
Speeds. Relative. The effect of, upon point where steamers will meet........ 253
Splice in rope................ 17
Splicing wire-rope 19, 20, 21
Spring:—
  The definition and use of.282-301
  The use of a, in working into a slip 292
Squall. To handle a boat in a 114, 116
Sprit-rig for Boats............ 110
Spun-yard 10, 11
Standing-Lug 110
Standing-part of a tackle. How made fast 65
Starting a tow ahead 355
Stay-tackle 67, 73
Stays. How fitted............ 27
Staying masts 32
Steam-Launch. Should be examined when hoisted...... 128
Steam-Launch machinery. Diseases of 124, 125
Steam Launches. Notes on Care and Handling of..122-130
Steam Pilot-vessels. Lights for 226
Steam vessels crossing. Rules of the Road for.......... 237, 245, 246, 247, 248
Steam vessels meeting. Rules of the Road for.......... 236
Steam vessels meeting in United States waters 245
Steam vessels crossing in United States waters 247
Steam vessels crossing at different speeds 253
Steam vessels crossing. Rules for Manœuvring of 253-262

- Steam vessels under sail by day. Shapes carried by... 230
- Steamers. Handling, alongside a dock.............. 282
- Steamers. Handling in Heavy Weather 334
- Steamers Manœuvring in a Hurricane 332
- Steamers. The steering of... 189
- Steering:—
  - by degrees 82
  - of Steamers, The........... 189
- Steering-Gear. Steam 3
  - Hand 4
  - Hydraulic 4
- Steering-Wheels 5
- Stern-boat. To lower a...... 108
- Stock-and-Bill tackle 68
- Stopped. Fog signals for a steamer 231
- Stoppers. Deck and Slip..... 153
- Stopping-power of ships...... 199
- Stopping. The space required by a steamer for......... 265
- Storm-wave of a hurricane.... 326
- Storms. Laws of............. 322
- Stowing Anchors 175, 176
- Stranding 367
- Stranded vessel. To get off a. 368
- Strapping blocks 62
- Strength of Rope............ 14
- Studs in Chain cable......148, 178
- Stun'sails. To set and take in 45, 368
- Surf. Handling boats in a.131-142
- Surf boats:—
  - Qualities needed for a...138, 139
  - Rescue of shipwrecked crew by means of.............. 370
- Surging the chain............ 155
- Swivel. Mooring 167
- Swivels 149
- Swivel-Shackle 149, 151

T.

- Tack. Midship 49
- Tackle. Friction in a.......62, 63
- Tackles 62
  - Different forms of 66
  - General remarks on reeving 65, 66
  - How designated 66
  - How rove for heavy work.. 65
  - Hauling part should lead from movable block 65
  - Power of 62, 63
  - Practical Rules for 69
  - Standing part of, how made fast 65
- Tacking a boat............... 116
- Tacking Ship 396, 397
- Taking in sail................ 375
- Telegraph cable:—
  - Lights for a vessel laying... 224
  - Fog-signals for vessels laying or picking up......... 232
- Tension on towline in smooth water towing ....
- Thomson's Sounding Machine 88-93
- Thrust on a yard in handling weights 73
- Tide:—
  - Effect of in handling a steamer alongside a dock....... 286
  - Effect of in working into a slip 293
  - Fair. Effect of in making a landing 289
  - Head. Effect of in making a landing 289
- Tidal currents:—
  - Change in direction of, from hour to hour..........289, 290
  - Indications of 273
  - Important to be familiar with (see Currents) 274, 275
- Tidal-Waves. Sometimes due to steaming into a sea.... 338
- Tides. Barometric 319
- Tiller. Arrangement of....... 4
- Top-burtons 67
- Topmast:—
  - cap. To ship the.......... 34
  - rigging 27
  - To get in and send up...... 32
  - To house a 37
  - To rig a 35
- Topgallant Masts. To send up and down 37, 39
- Topgallant sail. To set and take in 380, 381
- Topgallant yard. To send up and down 37, 38
- Topsail yards:—
  - Double 24
  - To get in.................. 35
  - To send up and down....... 36
- Topsails:—
  - Double 45
  - Making up for Bending..... 389
  - Reefing 383
  - To bend 389
  - To set and Take in......... 379
  - To shake the reefs out of the 385
- Torpedo Boats. Turning of.. 217
- Tow:—
  - Casting off a 348, 355
  - Overcoming inertia of...... 351
  - Taking a disabled vessel in.. 351

Towed:—
  Fog-signals for a vessel......232
  Lights for a vessel......223, 241
Towing:—
  Advantage of keeping ships "in step" 347
  alongside 298, 356
  Code of signals for use in.. 353
  Fog-signals for a vessel..... 232
  in smooth water. Use of wire-rope for 346
  Lights for a vessel......223, 241
  Lights in waters of United States 241, 242
  Engines 356
Towline:—
  chain, wire, and manila, compared 346, 347
  Requisites for a............ 346
  Tension on in towing in smooth water 350
  Securing on towing ship.347, 348
  Securing on towed ship..... 349
Trade-Winds 311, 312
Translation of a hurricane. Motion and velocity of...324, 326
Trawling. Description of..... 227
Trawlers. Lights for.227, 228, 243
Trim of boats for sailing...... 113
Tropical hurricanes. Origin of. 322
Trysail. To set and Take in.. 382
Tubes:—
  Chemical. For Sounding Machine 89
  Ground-glass for Sounding Machine 89
  of boilers of Steam Launches. To protect........... 127
Tugs:—
  Handling a large vessel with the aid of................ 298
  Towing alongside 298
  Used for handling steamers around a dock 286
Turning circles 195, 196, 197
Turning of Steamers..194, 195, 196
  197, 198, 207, 208, 211, 212
Turning in a limited space.... 207
Turning a steamer to pick up a man overboard......336, 337
Turning of Twin-screw ships.. 211, 212
Twin-screws:— 209
  Use of in handling a steamer around a dock......285, 289
Twin-screw Steamers. The turning of 211, 212
  Turning from rest......212, 213
  Lying-to 340
Types of ships 1, 2
Typhoons (see Hurricanes)... 322

U.

Unbending Sail 392
Unbitting a Cable............ 154
Underway. Definition of, in Rules of the Road........ 220
Underwater Valves. Inspection of in dry-dock............ 303
Undocking 297, 300

V.

Valves. Underwater. Care of, in dry-docking 303
Velocity of Wind, dependent upon barometric gradient. 308
Ventilation 5
Vertical Danger-angle 268
Vessel not under command. Lights for a 223
Voice. Use of the, for communicating in a fog...... 266

W.

Wake-current. Effect of, upon steering 190, 193
Water in boiler of Steam Launch 123, 126, 127
Watkins, S. W., Capt. S. S. Montana. Views upon lying-to in a Modern steamer 343
Waves. Period of, in connection with rolling.......... 337
Wearing in a boat............ 117
Weather:—
  and the Law of Storms..... 307
  accompanying a cyclone.308, 310
  Heavy. Handling a steamer in 334
  of North American continent 313
  prediction. Basis of 313, 314
Weather Maps 314
Weights:—
  Handling heavy 72
  Handling by derrick or sheers 75
  by a yard.................... 72
  No change to be made in, while ship is in dry-dock.. 305
  of Anchors. Table of....... 186
  of Hawsers. Table of....... 187
  of Chain cable.............. 187
Weighing Anchor 174
Westerlies or Passage winds. Explanation of 313
Whale-boat:—
  of United States Navy...... 95
  of whaling ships...........94, 95
Whisker-booms 26
Whips. Single 62
Whips. Water 68

Wilson-Barker, Capt. D., Paper by, upon Handling Ships. 344
Winches. To be run smoothly in handling weights....... 76
Winding a steamer at a dock. . 294, 295, 296
Winding a steamer in making a landing 296
Wind:—
  Circulation of, in a hurricane 323, 326
  General Circulation of...... 311
  Direction of, as related to barometric pressure 312
  Effect of, upon a ship backing 201, 215
  Velocity of, dependent upon barometric gradient 308
Windlass:—
  American Ship Windlass type 155
  Baxter's 157
Windlasses:—
  Directions for running and caring for 156, 157
  Modern. Advantages of.... 158
  Modern. How used for riding at anchor 159
  Modern. Nipping the cable by the brake 156, 158
Winding Pendant 72
Wire-hawsers for towing...... 13
Wire-rope 12
  Advantages and disadvantages of, for a towline.... 346, 347, 356
  Care of 13
  Flexible 12
  Manufacture of 12
  Safe-working load for....... 70
  To preserve 13
  used in United States Navy. 14
  Working in 18
  Working over a sheave..... 13
  Varieties of 12
Wood's Detaching Gear...... 104
Working load:—
  For Manila 69
  For Tackles 69
  For Wire-rope 70
Wreck. Rescuing the crew of a 358

Y.

Yards:— 23, 24
  Handling weights by........ 59
Yard-tackle 67
Yashima (Japanese Man-of-war) 196, 197, 216, 217

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